GODINA 8, BROJ 8 (2025)

ISSN 2566-4522

VISOKA ŠKOLA
"INTERNACIONALNA POSLOVNO-INFORMACIONA AKADEMIJA" TUZLA

ZBORNIK RADOVA

Book of Proceedings

8. MEĐUNARODNA NAUČNA KONFERENCIJA O DIGITALNOJ EKONOMIJI DIEC 2025

TUZLA, 2025. GODINA

GODINA 8, BROJ 8 (2025) ISSN 2566 - 4522

VISOKA ŠKOLA

“INTERNACIONALNA POSLOVNO–INFORMACIONA AKADEMIJA” TUZLA

ZBORNIK RADOVA

Book of Proceedings

8. MEĐUNARODNA NAUČNA KONFERENCIJA O DIGITALNOJ EKONOMIJI DIEC 2025

8th INTERNATIONAL SCIENTIFIC CONFERENCE ON DIGITAL ECONOMY DIEC 2025

TUZLA, 2025. GODINA

Izdavač / Publisher
Visoka škola za savremeno poslovanje, informacione tehnologije i tržišne komunikacije
"Internacionalna poslovno-informaciona akademija" Tuzla

ISSN 2566 - 4514 (*Print*)
ISSN 2566 - 4522 (*Online*)

CONTENTS

E-RECRUITMENT POWERED BY ARTIFICIAL INTELLIGENCE AND BLOCKCHAIN-BASED COMPETENCY PASSPORTS 5

THE DIGITAL EURO: A NEW ERA OF PUBLIC MONEY AND PRIVACY PROTECTION IN THE EUROZONE 27

(RE)EVOLUTION OF PERSONAL DATA PROTECTION IN BOSNIA AND HERZEGOVINA 45

CHATGPT, AI, AND THE FUTURE OF PRIVACY 57

DEVELOPMENT OF A MULTI-SECTORAL RISK AND RESILIENCE ASSESSMENT MODEL FOR SMART CITY: CASE STUDY OF FLOODS IN 2023 IN THE NORTH-EASTERN PART OF SLOVENIA 69

APPLICATION OF THE WOODWARD PROTECH 203 SAFETY SPEED CONTROLLER IN THERMAL POWER PLANTS 87

COMMUNICATION OF HEALTHCARE WORKERS WITH THE PUBLIC – WITH A SPECIAL FOCUS ON THE USE OF ICT 97

THE INFLUENCE OF DIGITAL TECHNOLOGY ON THE MARKET PERFORMANCE OF SMEs 113

INVESTIGATING THE IMPACT OF GENDER, AGE, AND INCOME ON CONSUMER ATTITUDES TOWARD ONLINE SHOPPING IN POST-PANDEMIC BOSNIA AND HERZEGOVINA 123

MODERN SOCIAL MEDIA ADVERTISING TRENDS 145

A MODEL FOR THE ECONOMIC EMPOWERMENT OF GIRLS AND YOUNG WOMEN 161

FACTORS AFFECTING THE INSURANCE - THE CONNECTION OF PERSONAL CHARACTERISTICS WITH INDIVIDUAL RISK MANAGEMENT 181

VIRTUAL FAITH: RELIGION IN BOSNIA AND HERZEGOVINA IN THE DIGITAL AGE. 197

Lazar Marković[1]
Aleksandra Labus[2]
Branka Rodić[3]
Danica Sovtić[4]
Aleksandra Trpkov[5]

Keynote paper

E-RECRUITMENT POWERED BY ARTIFICIAL INTELLIGENCE AND BLOCKCHAIN-BASED COMPETENCY PASSPORTS

Abstract

The digital transformation of human resource management is reshaping recruitment practices through the integration of advanced technologies, including artificial intelligence (AI) and blockchain. This paper examines the concept of e-recruitment facilitated by AI and blockchain-based competency passports, which consolidate verified records of formal and informal learning, certifications, and employment history. These passports, stored on a decentralized and tamper-proof blockchain ledger, provide candidates with secure, portable, and verifiable digital identities. Upon consent, employers and recruiters can access a candidate's credentialed background, enabling faster and more accurate pre-selection while reducing reliance on manual verification. AI algorithms enhance the recruitment process by analyzing competency data, matching candidates to job profiles, predicting performance, and identifying potential risks. The combination of these technologies enables more transparent, efficient, and fair hiring processes, while also ensuring that candidates retain control over their personal data. This paper presents a developed model of the ecosystem for e-recruitment based on AI and blockchain highlighting the roles and technology-enabled processes of key stakeholders, including candidates, educational institutions, employers, HR departments, and regulatory bodies. The model offers a comprehensive view of how emerging technologies can be effectively embedded throughout the recruitment life cycle. Furthermore, the study elaborates on the system's technical architecture, discusses challenges such as legal compliance and interoperability, and proposes strategic recommendations for gradual adoption.

Key words: *Human Resource Management, E-recruitment, Blockchain, Artificial intelligence, Competency Passport.*

1 PhD student, University of Belgrade Faculty of Organizational Sciences, Serbia, lmarkovicbb@gmail.com
2 Full professor, University of Belgrade Faculty of Organizational Sciences, Serbia, aleksandra.labus@fon.bg.ac.rs
3 Full professor, The College of Health Sciences, Academy of Applied Studies Belgrade, Serbia, brodic@gmail.com
4 PhD student, University of Belgrade Faculty of Organizational Sciences, Serbia, danica.sovtic@gmail.com
5 PhD student, University of Belgrade Faculty of Organizational Sciences, Serbia, aleksandratrpkov1@gmail.com

1. Introduction

The rapid advancement of digital technologies has significantly influenced the transformation of human resource management (HRM), particularly in the domain of recruitment. Traditional hiring practices are increasingly being replaced or enhanced by technology-supported approaches that prioritize data accuracy, automation, and transparency (Kim et al., 2020). Among these technologies, AI and blockchain stand out as key enablers of innovation in e-recruitment. AI facilitates intelligent decision-making by analyzing candidate data, matching profiles to job requirements, and predicting potential performance or risk factors. At the same time, blockchain ensures the integrity and authenticity of candidates' credentials, offering a decentralized and tamper-resistant method for managing educational, professional, and competency records. In combination, these technologies establish the foundation for more efficient, trustworthy, and candidate-centric recruitment processes (Black & van Esch, 2020).

Traditional recruitment platforms are typically limited in scope, often functioning as static job boards or tools for initiating basic contact between employers and candidates. In contrast, AI and blockchain introduce deeper structural changes to the recruitment process. AI enables advanced automation of candidate selection, competency matching, and performance prediction, significantly reducing the time and cost associated with hiring (Ucha et al., 2024). Blockchain enables the creation of verifiable digital competency passports that aggregate formal education, informal learning, and work history into a single, secure profile controlled by the individual. This transition from fragmented CVs to verified digital identities enhances both transparency and reliability, offering added value for all participants in the employment ecosystem (Enis Dorlevi, 2024).

The primary objective of this paper is to develop and present a conceptual model of an e-recruitment ecosystem based on the integration of AI and blockchain technologies. The model incorporates blockchain-based competency passports that consolidate formal and informal learning records, certifications, and employment history into secure digital identities. By granting consent-based access to these credentials, candidates can streamline the recruitment process, while employers benefit from greater reliability, reduced administrative burden, and improved accuracy during pre-selection. This ecosystem promotes not only operational efficiency but also fairness, data privacy, and empowerment of individuals within the labor market.

The structure of the paper is as follows: Section 2 provides a theoretical background, including the role of digital transformation in HRM and the application of AI and blockchain in recruitment and lifelong learning. Section 3 introduces the proposed model of the e-recruitment ecosystem, explaining its components, key stakeholders, technological mechanisms, and legal considerations. Section 4 presents the concluding remarks, summarizing the findings and contributions of the study. Finally, Section 5 outlines directions for future work, with a focus on practical implementation and further research opportunities.

2. Theoretical Background

2.1. Digital Transformation of Human Resource Management

At the very beginning, personnel management mainly dealt with recruitment and selection, and training and development initially focused on improving efficiency through hiring and training. HRM now seeks to foster a positive work environment, support employee health, and align individual goals with those of the organization, emphasizing not only efficiency but also mental and social aspects of work (Li & Estacio, 2024). This shift reflects the broader societal move toward enhancing human function, productivity, and quality of life through science and innovation (Li & Estacio, 2024).

HRM has significantly broadened its scope in the digital age, driven by the influence of customer behavior, demographic expectations, and product evaluations on organizational success. One of the most significant transformations brought by digitalization is the emergence of electronic recruitment (e-recruitment). E-recruitment refers to the use of digital technologies, such as online platforms, social media, and applicant tracking systems, to attract, assess, and hire job candidates. It enables organizations to reach a broader pool of applicants, streamline the hiring process through automation, and improve communication between employers and candidates (Milovanović et al., 2022). The evolution of e-recruitment has profoundly impacted HRM by introducing online platforms, social media, and applicant tracking systems that have reshaped how organizations attract, evaluate, and hire talent. These tools save time, reduce administrative burdens, and improve communication between candidates and employers, making the process more efficient and transparent (Kroll et al., 2021). As a result, HRM must continually adapt and integrate emerging technologies to meet the evolving demands of both business and the workforce. HRM has evolved into a strategic human resource over the past century. It went from simple personnel functions to a strategic role that views employees as key drivers of organizational success. This shift reflects changing business priorities and the growing importance of aligning people strategies with overall goals. Modern recruitment is increasingly complex, facing several critical challenges (Rozario et al., 2019). Despite the advantages of digital platforms, challenges remain, such as a persistent skills mismatch and the risk of fake credentials, which require HRM to invest more in reskilling and verification processes. Furthermore, even automated systems risk perpetuating biases or errors if the data and algorithms are flawed, underscoring the need for reliable and ethical design of recruitment technologies (Black & van Esch, 2020; Kroll et al., 2021). One of the most pressing issues is the skill mismatch between available job candidates and the evolving needs of industries. As sectors rapidly adopt technologies such as AI, the Internet of Things (IoT), and advanced data analytics, a widening gap is emerging between the skills organizations require and those currently possessed by the workforce. Many candidates lack the technical proficiency to manage large datasets or utilize digital tools essential in modern workplaces. This places a greater burden on HRM to invest in training and development initiatives that align employee capa-

bilities with technological demands. Another significant challenge is the proliferation of fake credentials. The increase in remote and online hiring practices has made it easier for individuals to misrepresent their qualifications or work experience. Verifying educational degrees, certifications, and past employment has become more difficult and time-consuming, especially when done manually. Manually checking credentials can be a tedious and time-consuming task, and even the most diligent recruiters are not immune to occasional mistakes. These errors can sometimes lead to unqualified candidates slipping through the cracks and being hired, which can have serious consequences for team performance and trust in the recruitment process. Furthermore, the inefficiencies of manual screening complicate the recruitment process. Manually reviewing hundreds or thousands of applications consumes valuable time and often results in inconsistent evaluations due to subjective biases or recruiter fatigue. Although electronic HRM (e-HRM) systems have introduced automation into the process, their effectiveness largely depends on the quality and accuracy of the input data. Without robust data integrity and fair algorithmic design, these systems risk excluding qualified candidates or perpetuating biases (Kroll et al., 2021). Altogether, these challenges highlight the urgent need for HR departments to adopt more reliable, data-driven, and technology-enhanced recruitment strategies that can keep pace with the demands of today's dynamic labor market.

2.2. Blockchain in Lifelong Learning and Competency Management

Lifelong learning refers to the ongoing, voluntary, and self-motivated pursuit of knowledge, skills, and competencies throughout an individual's life, for personal, civic, social, or professional purposes (Laal, 2011). According to UNESCO, lifelong learning spans all age groups, learning contexts, and modalities: formal, non-formal, and informal, and is recognized as essential for individual growth and achieving sustainable development goals (English & Carlsen, 2019). Formal education typically occurs within structured, institutional settings, such as schools, colleges, and universities. It follows a defined curriculum, has clear learning objectives, and typically leads to recognized certifications or degrees. This modality is intentionally organized and regulated, providing learners with credentialed outcomes aligned with recognized standards. Non-formal education refers to planned and organized learning activities that occur outside the formal education system. These may include workshops, seminars, community courses, or vocational training programs designed to serve specific learning objectives, often without leading to formal certification. While purposeful and structured, non-formal education is typically more flexible and responsive to learner needs than formal education (Council of Europe, 2000; UNESCO, 2020).

Blockchain technology empowers the recognition of diverse learning experiences, including formal, informal, and non-formal education, by offering a secure, immutable, and decentralized platform for storing and verifying credentials. Blockchain is a distributed and immutable digital ledger that securely records transactions without the need for a central authority. Its key characteristics include decentralization, immutability, and transparency, making it suitable for ap-

plications that require trust and data integrity (Bogdanović et al., 2019; Trpkov et al., 2024; Sovtić et al., 2025). Every earned credential, ranging from academic degrees to micro-credentials, badges, and workplace achievements, can be recorded on a blockchain ledger, ensuring tamper-proof verifiability and reducing the risk of fraud (Das, 2024; Suktam et al., 2024; de Alwis et al., 2025). Through blockchain-based credentialing systems like MIT's Blockcerts and the European blockchain services infrastructure (EBSI), learners gain ownership over their educational records and can share them with employers or institutions reliably and efficiently. MIT pioneered the Blockcerts initiative through its Media Lab, introducing a blockchain-based system for issuing academic diplomas and certificates digitally. Graduates receive credentials stored in a personal wallet and linked to their public-private key pair, allowing third parties, like employers or universities, to verify authenticity independently without contacting an issuing institution (MIT, 2017; Sven Kamieth, 2023).

EBSI is a public-sector blockchain initiative launched in 2018 by the European Commission and 29 European countries. It provides a decentralized infrastructure for issuing and verifying digital credentials, such as diplomas and micro-credentials, securely across borders using digital wallets, verifiable credentials, and blockchain technology (EBSI, 2025). Key use cases include the issuance of eDiplomas and transcripts of records, which can be stored in personal digital wallets and verified instantly by universities during admissions, significantly reducing bureaucratic delays and fraud risk (EBSI, 2015).

The "competency passport" is a blockchain-based digital portfolio that securely stores an individual's credentials, certifications, skills, and employment history on a decentralized ledger (Jirgensons & Kapenieks, 2018). Unlike traditional CVs or centralized databases, this passport offers verifiable, tamper-proof proof of competencies, allowing individuals to present a trusted, comprehensive record of their learning and work achievements across formal, non-formal, and informal contexts (Enis Dorlevi, 2024; Satyabrata Das, 2024). Built on blockchain, the competency passport ensures portability, enabling users to carry their credentials seamlessly across borders, institutions, and employers without repeated verification processes. For instance, a person who studied in one country, received technical training in another, and gained work experience elsewhere can share a single verifiable record worldwide. This is particularly useful in today's mobile and globalized job market.

A key benefit is that the blockchain's immutable nature protects against data tampering and credential fraud. All records are timestamped and cryptographically secured, making it extremely difficult to forge or alter qualifications once issued. This strengthens trust between applicants, employers, and educational institutions. Moreover, the competency passport supports ownership by the individual. Learners control access to their data, decide who can view or verify it, and maintain lifelong access to their portfolio, even if an issuing institution ceases to exist. This shift to a learner-centered model empowers individuals and enhances transparency in hiring, admissions, and credential recognition. Projects like EBSI are actively exploring or implementing competency passports as part of broader efforts to modernize digital credentialing in education and

employment. In essence, a competency passport built on blockchain establishes a trusted, user-controlled learning portfolio that is secure, portable, and verifiable, bridging gaps in traditional credentialing systems (VerifyEd, 2025).

2.3. Blockchain in HRM

Blockchain technology is increasingly recognized in HRM for its role in ensuring the authenticity and immutability of data. At its core, a blockchain is a decentralized ledger of transactions or records, secured through cryptography and consensus mechanisms (Trpkov et al., 2024). Once data is written to a blockchain, it cannot be altered retroactively without breaking the chain of subsequent blocks. This immutability guarantees that HR data, such as credentials or work history, remains tamper-proof and verifiable (Kim et al., 2020; Anaam et al., 2023). In recruitment, this property addresses longstanding issues of resume fraud and credential falsification: a candidate's documents (e.g., diplomas, certificates) can be verified directly from the source (the issuing institution) with no intermediary, improving information reliability and building trust between employers and candidates (Kişi, 2022). By creating an immutable record of each candidate's qualifications and achievements, blockchain offers a single source of truth that all parties can trust. One powerful application of blockchain in HRM is credential verification. Instead of requesting paper certificates or contacting universities, employers can instantly validate a candidate's degrees, certifications, or work experience if these credentials are issued as blockchain records. The Velocity Network, for example, is developing a global blockchain network for verified career credentials. In such a network, everyone can hold a "digital career passport" containing their verified education and skill records. This is a "digital passport that employees can carry from one place of employment to the next," allowing hiring managers to compare candidates on a level playing field with pre-verified data. Real-world implementations are emerging for instance, IBM's "Skill Wallet" similarly allows users to manage and share blockchain-verified skills and certifications across platforms. Likewise, the European Union's Europass Digital Credentials project explores portable, cryptographically secure credentials, giving employers confidence in their authenticity (Mazharunnisa et al., 2024).

Blockchain also enhances secure identity management and candidate data privacy in recruitment. Traditional recruitment platforms often centralize sensitive personal data, creating a single point of failure. In contrast, blockchain allows personal data to be stored in a decentralized manner, with candidates retaining control via private keys, aligning with the concept of self-sovereign identity (SSI) (Kandpal et al., 2023; Mazharunnisa et al., 2024). This ensures privacy compliance while empowering candidates to decide which parts of their data to share and with whom. By eliminating a single point of failure, blockchain greatly reduces the risk of unauthorized data access or leaks (Kim et al., 2020; Anaam et al., 2023). For example, a job seeker could maintain ownership of their profile on a blockchain and only permit recruiters to view certain verified details (such as a skill certificate or employment record). This candidate-centric data control not only improves privacy compliance (e.g., with data protection

regulations) but also empowers individuals in the hiring process, potentially improving their willingness to participate in digital credential platforms. Transparency and trust are further strengthened because every credential or update is time-stamped and visible to authorized parties, building confidence in the accuracy of information (Peisl & Shah, 2019; Ucha et al., 2024). Employers can trust that a candidate's blockchain-based profile is an accurate representation of their qualifications, as any attempt to fabricate credentials would be evident and computationally infeasible to hide. For candidates, this mechanism can level the playing field: those with rich skill sets but non-traditional backgrounds can prove their competencies with verifiable records, helping to overcome bias based on proxy indicators like university prestige (Ucha et al., 2024). A decentralized record of achievements also facilitates lifelong career development, allowing workers to accumulate verified "blocks" of skills and experiences throughout their career. Beyond recruitment, smart contracts (self-executing programs on a blockchain) can automate HR processes that require trust and verification. For example, a smart contract could automatically release a signing bonus once a new hire's onboarding steps are completed, or trigger payroll payments based on recorded hours, without manual intervention. The study (Mazharunnisa et al., 2024) noted that by creating immutable records and automating verification, blockchain sped up candidate background checks and reduced certain HR processing costs. By eliminating intermediaries and manual steps, organizations can streamline hiring workflows. However, these benefits come with challenges. Infrastructure and implementation costs for blockchain in HR can be high, and there is a need for clear regulations and standards (Idris, 2025). Moreover, achieving industry-wide adoption of competency passports will require common taxonomies and cooperation across organizations. Despite these hurdles, recent studies agree that blockchain holds great promise for making e-recruitment more secure, efficient, and trustworthy (Idris, 2025). As organizations continue to pilot blockchain-based credential platforms, we can expect the "competency passport" approach to gain traction, enabling a future where candidates and employers transact in verified, reliable information with unprecedented ease.

2.4. Artificial Intelligence in HRM

AI has become a transformative force in HRM, especially in recruitment and talent management. AI techniques, including machine learning, natural language processing, and predictive analytics, are being applied to automate and enhance various stages of the hiring process. This section examines key AI applications in HRM: candidate screening, job matching, predictive analytics for hiring, AI-driven identification of skill gaps, performance prediction, and the ethical considerations that arise from these practices.

AI in candidate screening. One of the most widespread uses of AI in recruitment is to streamline the screening of job applicants. AI-powered applicant tracking systems (ATS) can parse resumes and applications at high speed, automatically shortlisting candidates whose profiles match the job requirements. This dramatically reduces the manual workload for HR teams in the initial

screening phase. Studies have found that AI can cut down screening time significantly. AI tools expedite the filtering of resumes by scanning for experience, skills, and keywords much faster than humans can, thus reducing time-to-hire by up to 50% in some cases. In practice, chatbots and virtual assistants further assist in screening by handling routine applicant queries and even conducting preliminary interviews. These AI chatbots can ask candidates basic questions about their experience or availability and use natural language processing to evaluate the responses. By handling repetitive interactions, AI frees up human recruiters to focus on higher-level tasks (Black & van Esch, 2020). Surveys indicate that a majority of recruiters, about 75% of them, reported that AI tools help them quickly screen resumes and identify top candidates, thereby speeding up the hiring process. AI-based screening is also expanding beyond text resumes: some companies deploy AI video analysis for initial interviews, using algorithms to evaluate speech patterns and facial cues (Bogen & Rieke, 2018). While these approaches remain controversial, they exemplify how deeply AI is penetrating the recruitment funnel.

AI in job matching. Beyond screening for basic qualifications, AI is improving how candidates are matched to the right roles. Machine learning models can be trained on successful employee profiles to discern which applicant attributes (skills, career trajectory, even cultural fit indicators) correlate with success in specific roles. They then use this knowledge to recommend candidates whose profiles best match a particular job posting. Modern job platforms leverage AI recommender systems to suggest job opportunities to candidates and, conversely, to suggest suitable candidates to recruiters, much like a dating app for jobs. According to industry analyses, such talent–job matching algorithms can markedly increase the quality of hires: predictive analytics have been shown to improve talent matching by as much as 67%, meaning the selected candidates are far more likely to meet or exceed performance expectations in their new role (Allal-Chérif et al., 2021). For example, LinkedIn and Indeed's recruitment AI engines analyze millions of data points from profiles and job descriptions to identify matches that a human recruiter might overlook. This is particularly useful for finding candidates with unconventional career paths or transferable skills that fit a role. Additionally, AI can factor in more complex patterns, such as combining skills (technical + soft skills) to find applicants who align with a company's needs and culture. Companies adopting AI for talent acquisition gained a competitive edge by better understanding candidate profiles and identifying high-potential talent more effectively than competitors (Leicht-Deobald et al., 2019). In short, AI augments the pattern-matching that good recruiters have always done, but on a vastly larger scale and with data-driven objectivity.

Predictive analytics in hiring. Perhaps one of the most promising aspects of AI in HRM is its ability to analyze historical data and predict future outcomes. In recruitment, predictive analytics can forecast which candidates are likely to become top performers, who might have longer tenure, or which new hires might need additional training, thereby informing hiring and talent development decisions. Some organizations now use AI models built on employee performance data to assess incoming candidates. These models look at the traits and expe-

riences of past successful employees in a role and score candidates on how closely they resemble those profiles (Tambe et al., 2019). Such data-driven predictions can supplement the intuition of hiring managers with evidence-based insights, sometimes called "people analytics" or talent analytics in HR. Predictive algorithms are also used to anticipate hiring needs: by analyzing patterns like turnover rates, business growth, and skill gaps, AI can project what roles will likely need filling shortly and what competencies will be in demand (Tambe et al., 2019). A survey by CareerBuilder found that 55% of U.S. HR managers expected AI to be a regular part of their work within five years, particularly for its predictive capabilities in workforce planning. In practice, AI-driven predictive analytics have achieved notable accuracy in certain areas; for instance, modern analytics can predict employee turnover with up to 87% accuracy according to some reports (Allal-Chérif et al., 2021). This allows HR departments to proactively engage in retention efforts or succession planning. In recruitment, predictive tools can flag which candidates might become high performers based on their psychometric test results or even digital footprints. However, it is important to use these predictions carefully and in combination with human judgment, to avoid over-reliance on what are ultimately probabilistic forecasts.

Identifying skill gaps with AI. Beyond hiring, AI also contributes to internal HRM by analyzing employees' skills and performance, thereby identifying skill gaps within the organization. In the context of e-recruitment and competency passports, this is highly relevant. The ultimate goal is not just to hire talent, but to ensure that their skills are continually developed and aligned with organizational needs. AI systems can aggregate data from assessments, on-the-job performance metrics, training records, and even learning management systems to create a skills inventory of the workforce. Using this data, AI can highlight gaps between the current skill set of employees and the skills required to achieve future business goals. AI-driven platforms like Cornerstone's Skill Graph or Workday's Talent Insights can recommend personalized learning paths for employees to close these gaps. In recruitment, this insight can shape hiring criteria companies can prioritize candidates who bring in skills that are underrepresented in the existing team. Predictive analytics also comes into play: AI might predict what new skills will become critical for the industry in the coming years (using trends from job market data or strategic forecasting) and prompt HR to start building those skills now, either by hiring fresh talent or retraining current staff (Allal-Chérif et al., 2021). Moreover, AI can evaluate the effectiveness of training programs by monitoring performance improvements, thereby continuously refining the approach to skill development. The use of AI for skill gap analysis thus feeds directly into recruitment strategies: if internal upskilling cannot fill a gap fast enough, the recruitment team knows exactly what profile to target externally, making hiring more strategic and future-focused.

Performance prediction and talent analytics. In tandem with identifying skill gaps, AI is increasingly used to predict employee performance and other important HR outcomes. Machine learning models can analyze indicators from the hiring process (such as assessment scores, interview data, or even tone analysis from video interviews) and find correlations with later performance

on the job. For example, an AI system might learn that candidates who exhibit certain language in interviews or have project experiences tend to become high performers in sales roles. Using such insights, organizations attempt to refine selection criteria to choose candidates with the highest predicted performance trajectory. Some vendors offer AI assessments that claim to evaluate cognitive abilities, personality traits, or emotional intelligence in a way that correlates with job success (often using gamified tests or scenario simulations). These tools can provide a performance prediction score for each candidate. Research has shown that AI can sometimes predict aspects like leadership potential with reasonable accuracy. One report noted an AI-based evaluation could predict leadership potential with about 80% accuracy. AI is also used for predicting outcomes like cultural fit, engagement, or likelihood of promotion, although these areas are more complex and potentially sensitive. Additionally, within organizations, AI-powered analytics continuously monitor performance data to identify who might be ready for advancement or who might be struggling and in need of support. This overlaps with predictive HR analytics (also known as "people analytics"), which many large firms have embraced. Importantly, while these predictive tools can be powerful, they raise questions about transparency and fairness (as discussed below in ethics). Companies like Google have long used data analytics to inform HR decisions (e.g., identifying what makes a great manager or predicting attrition), demonstrating the value of data-driven predictions. When carefully validated, performance-prediction models can help reduce the bias of subjective evaluations by focusing on data. However, if not validated, they can also reinforce biases present in the training data. Therefore, best practice calls for human oversight and periodic audits of any AI performance prediction system (Raghavan et al., 2020).

Ethical considerations in AI-driven hiring. The deployment of AI in recruitment and HRM brings significant ethical challenges that organizations must address. A foremost concern is algorithmic bias and fairness. AI systems learn from historical data in recruitment, which may be data about past hiring decisions or employee performance. If historical data reflect biases (e.g., a past preference for certain demographics or schools), the AI can inadvertently inherit and amplify discriminatory patterns. A now-classic example is Amazon's experimental AI hiring tool, which was found to be biased against female candidates because it learned from the company's male-dominated hiring history. The AI systematically downgraded résumés containing the word "women's" (as in "women's sports team") because such resumes were historically less frequent among successful hires. Amazon ultimately scrapped the project, and this case stands as a cautionary tale. Chen (2023) highlights that algorithmic bias in AI-enabled recruitment can lead to discriminatory hiring outcomes based on gender, race, and other traits, often because the training data is limited or biased (Leicht-Deobald et al., 2019). This has prompted calls for "algorithmic audits" of HR AI tools and for the development of fairness-aware machine learning techniques. Another ethical consideration is transparency and explainability. Many AI algorithms, especially complex machine learning models like deep neural networks, operate as "black boxes" that offer little explanation for their decisions. In hiring, this opacity is problematic: candidates may justifiably want to know why

they were screened out by an AI system or what factors led to a low fit score. From an ethical and legal standpoint, a lack of explanation can make it hard to contest a potentially unfair decision. Regulatory bodies and scholars argue for "algorithmic transparency" in recruitment, meaning candidates should be informed when AI is used and, ideally, given some insight into how decisions were made. Some companies have started addressing this by using more interpretable models or providing reason codes ("candidate lacked required certification X") generated by the AI. However, achieving true explainability remains a technical challenge. Accountability for AI decisions is also key: ultimately, employers cannot abdicate responsibility to a machine. Best practices suggest maintaining a "human-in-the-loop" approach, where human recruiters make the final decisions or at least review AI-generated recommendations, especially on sensitive matters (Bogen & Rieke, 2018). Privacy is another ethical dimension. AI systems often harvest a wide array of data, including social media profiles, public records, or even facial data from video interviews to feed their algorithms. This raises privacy concerns about how much data is appropriate to use in hiring and whether candidates have given informed consent. Ethical hiring practice calls for using only job-relevant data and ensuring compliance with privacy laws such as GDPR in Europe. Lastly, there is the question of ethical design and governance of AI in HR. Organizations are increasingly establishing AI ethics committees or guidelines to oversee the tools used for people's decisions. One recommendation is to implement bias mitigation strategies in the AI development phase by training models on diverse data, testing them for disparate impact on different demographic groups, and correcting any bias found (Raghavan et al., 2020; Chen, 2023). Technical solutions like bias-correcting algorithms and diverse training datasets can help, but managerial measures are equally important. Another approach is to involve stakeholders in AI system design, e.g., getting input from HR professionals, legal experts, and even candidates to identify potential ethical pitfalls early.

In summary, while AI offers powerful capabilities to improve efficiency and decisions in recruitment (e.g., faster screening, better matching, predictive insights), it also poses ethical challenges that must be proactively managed. Ensuring fairness, transparency, privacy, and accountability in AI-driven hiring is essential to maintain trust in these systems. Companies deploying AI in HRM should adhere to the principle often quoted in this domain: augment, not replace. AI should assist human decision-makers, not completely supplant them, and organizations must remain accountable for the outcomes (Bornstein, 2018).

3. Model of Ecosystem for e-Recruitment Based on AI and Blockchain

3.1. Overview of the Ecosystem

This paper presents the development of a model of an ecosystem for e-recruitment based on AI and blockchain, involving key stakeholders such as government and regulatory bodies, educational institutions, recruitment agencies, in-house HR personnel, job placement platforms, employers, and candidates (Figure 1). At its core is a multi-layered stack: AI engines semantically profile and

automatically parse the e-passport of each candidate, make predictive analytics-based screening decisions, rank, and provide chatbot-enabled engagement automatically. Blockchain Platform offers decentralized identity management, smart-contract-based credential verification, an immutable digital ledger, and granular consent controls. Cloud database stores scanned diplomas, portfolios and interview recordings off-chain with end-to-end encryption, auto-scaling storage, high availability and secure APIs. Big Data layer aggregates millions of anonymized records into live recruitment dashboards, talent pool analytics, behavioral insights, and skill-gap mapping (Qin et al., 2018). All these inputs fuel the candidate's competency passport, a safe digital file holding work history, academic record, licenses and certifications, technical knowledge and skills, core abilities, training record, language, and personal interests. From this safe source, the system completes uniform Curriculum Vitae that can be retrieved on demand by rightful stakeholders. Blockchain guarantees data integrity and open audit trails. AI builds and scores profiles to best fit into jobs; the cloud layer offers scalable, resilient access to documents, and big data interprets raw records into HR strategy, all under candidates' full control of who gets to see what part of their digital profile (Bhatia et al., 2019).

Blockchain platform. At its core is a decentralized identity layer of management: every competency passport is the self-sovereign digital identity of the candidate. There is no centralized database of personal information; rather, cryptography keys define what can be seen by whom and when (Mishra & Venkatesan, 2021). All credentials, such as degree, language certification, or professional title, are stored in the immutable credential registry as a tamper-evident hash. When an issuing organization or certifying authority issues a document, a smart contract releases a blockchain record; when the same recruiter later asks for verification, the same contract can verify immediately its validity and issue date. Smart contract orchestration avoids human back-and-forth with issuing organizations, significantly speeding up background checks. Since we run a permissioned consortium network, only approved participants, employers, HR agencies, and accrediting agencies may read or write to the ledger. All access actions are recorded in an audit trail, so there is complete visibility of who looked at or approved which credential. No less important, consent management capability allows candidates to create and withdraw access to individual data points on demand, so showing a language certificate to one recruiter need not involve displaying salary history or personal references to another (Koncheva et al., 2019).

Artificial Intelligence. Automated screening and ranking systems based on resume parsing and semantic profiling transform unstructured text, project titles, job roles, certificates into normalized data fields (Sharma et al., 2025). Algorithms then filter out incomplete or irrelevant applications, while candidate job fit models, trained on historical hiring data, quantify how well a competency passport aligns with a role's requirements. AI-driven job matching algorithms can proactively suggest the most relevant positions to candidates based on their competency passports, boosting engagement and reducing time to fill. Performance prediction models leverage both historical and real-time data to

forecast not only immediate role fit but also long-term career trajectories. Regular model retraining, combined with ethical oversight and bias-detection routines, ensures that AI recommendations remain fair, transparent and aligned with organizational values (Qin et al., 2018). Predictive analytics analyzes attrition risk, time-to-productivity, and long-term retention, while AI-based skill-gap analysis identifies where upskilling needs to happen and predicts on-job performance. Virtual chatbots and assistants allow the candidates to converse in a natural manner, status of the application, asking for personalized recommendations on enhancing the profile, or scheduling interviews, without any explicit human mediation. During the process, ethical practices are employed, such as routine bias audits and explainability reports, in ensuring fairness, transparency, and conformance with organizational values.

Cloud database. While blockchain roots trust, the cloud database holds mas-

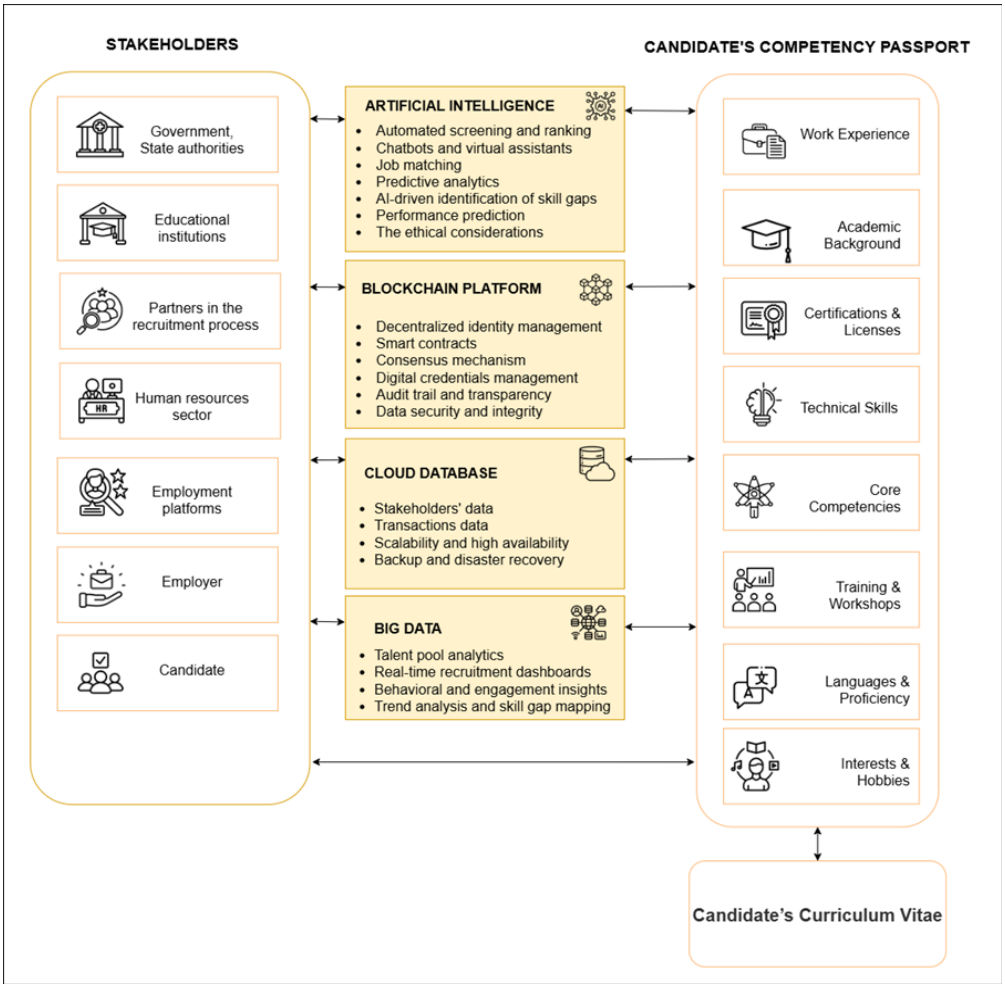


Figure 1. Model of Ecosystem for E-Recruitment Based on AI and Blockchain

sive artifacts and metadata, such as scanned diplomas, portfolio PDFs, interview recordings, and off-chain data to guarantee performance and scalability. Each file is encrypted when at rest and when in transit, with keys stored in the candidate's identity wallet so that only permitted viewers can decrypt the content (Odun-Ayo Isaac et al., 2017). The cloud layer dynamically scales storage and compute to support thousands, if not millions, of profiles with sub-second response times during peak-volume hiring. A safe API gateway only provides analytics tools with the data they need. And with geo-redundant backup and native disaster recovery, candidate records never go dark even if a region goes down.

Big data. With candidate profiles stored and securely indexed, the stack of big data pools millions of anonymized records to propel strategic insights. Talent pool analytics expose total distributions of levels of seniority and education skills, enabling organizations to compare themselves with the market (Nocker & Sena, 2019). Hiring groups are provided with live dashboards displaying crucial metrics, time-to-hire, pipeline velocity, along with diversity and inclusion metrics, such as gender mix or geographic spread, and these metrics come directly from immutable credential data.

3.2. Stakeholders and Their Roles

All the players in the ecosystem for e-recruitment based on AI and blockchain play a crucial part in crafting an open, secure, and efficient recruitment process. Through sharing information using decentralized protocols and sophisticated analytics, such a model guarantees real-time validation, button-click profiling, and secure access control of candidate data.

Government and state authorities. They manage conformity to security and legal standards for the system, issuing and verifying official certificates, certificates of no criminal record, and other documents to which applicants attach their competency passports. Through the regulation of digital identity schemes, they ensure all personal data is treated responsibly and according to governing legislation (Koman et al., 2024).

Educational institutions. Universities, colleges, and schools put academic qualifications on the blockchain. Each course diploma or certificate is hashed and saved by a smart contract, creating an irreversible timestamped record of proof of issuance and origin. This removes the necessity for manual confirmation and renders academic credentials easily verifiable by anyone (Okolie & Irabor, 2017).

Partners in the recruitment process. Agencies, recruiters, and individual sourcers mix and merge AI technology with blockchain-validated authentication for performing high-speed pre-screening (Aljuaid, 2021). They scavenge e-passports from multiple sources, use semantic profiling, shortlist applicants based on mutually agreed parameters, and provide shortlists of the best-fit applicants to corporate HR functions. Their responses continue to refine the big-data analytics layer, making subsequent talent-sourcing even more target-

ed.

Human resources sector. Hiring Managers within the corporation design recruiting policies and procedures and oversee automated workflows. They establish AI-driven fit scores, monitor candidate pipelines through real-time dashboards, and oversee fine-grained data access entitlements (Anghel, 2023). Once the candidates have been matched with pre-set parameters, HR managers automate interview invitations or make job offers, based on the immutable audit trail for end-to-end visibility of processes.

Employment platforms. Internet job boards and career sites are utilized as the primary points of intake for e-passports and first-time candidate introductions. They talk to cloud-based APIs to pull in only the profile data needed for each job, so application flow is simple. This makes the distribution of live profiles to many sites for candidates possible and allows employers to be able to rapidly search and sift through desired talent (Dillahunt et al., 2021).

Employer. Hiring organizations set up work requirements and place essential offer terms, compensation, benefits, and start date into smart contracts. A contract executed digitally with an on-chain seal initiates a permanent record of acceptance in the audit trail. Automation from end to end solves administrative overhead, speeds up offer completion and preserves legal enforceability.

Candidate. Lastly, candidates completely own their self-sovereign competency passport, a safe digital document with work history, education history, certificates, skill sets, training, language ability, and hobbies. With advanced consent settings, they control precisely what to disclose, to whom, and for how long. An AI layer helps them to maximize their profile and easily create a default Curriculum Vitae, while remaining transparent and secure along their career journey.

3.3. Smart Contracts and Automation

HR industry smart contracts are independent, self-sufficient code blocks on the blockchain that perform the most important tasks of verification, consent management, and candidate approval. The instant a diploma or certificate is handed over by an educational organization or certifying authority, its smart contract hashes and gets saved automatically on the immutable ledger, eliminating manual checks for validity. In the same vein, applicants are also given a means for fine-grained access control; they can allow or deny granting the right to read specific sections of their e-passport, and each choice and application is recorded within the audit trail by the smart contract and enforced to comply with General Data Protection Regulation (GDPR) and other laws (Aleisa et al., 2022). In a prospective hiring situation, smart contracts can be written to work together with the AI layer in such a way that if a candidate possesses a certain predetermined threshold of fit score, the contract would automatically initiate inviting them for an interview or shortlisting them, without human intervention (Abdullah et al., 2024). If the candidate accepts and agrees to the terms of the offer, the smart contract will convert the important parameters (salary, benefits, start date) into a digital agreement, and the on-chain signature of the candidate

would automatically sign off on the agreement, effectively giving an immutable record of the agreement. This response could be likely to accelerate timescales, decrease administration costs, and have a completely transparent audit trail of every step (Abdullah et al., 2024).

3.4. Legal and Regulatory Considerations

In any blockchain-and-AI-driven e-recruitment system, data privacy is paramount. Regulations such as the EU's GDPR require that personal data be processed lawfully, transparently, and for defined purposes only. Immutable blockchains conflict with the "right to be forgotten," so off-chain storage with on-chain pointers, strong encryption, and pseudonymization are necessary to respect erasure and rectification requests. Explicit, granular consent mechanisms must log each data sharing event, while AI profiling layers need to be audited for bias and documented in a privacy impact assessment (Zyskind et al., 2015). Cross-border recruitment compounds these challenges. Digital identity legislation varies dramatically, from the EU's eIDAS framework to the U.S. state-level privacy laws and Asia's emerging e-ID schemes, making interoperability and mutual recognition of credentials difficult. Compliance teams must navigate anti-money laundering (AML) and know-your-customer (KYC) rules when verifying overseas applicants, often relying on legally accredited trust frameworks or bilateral agreements. To ensure portability, credential issuers should adopt open standards (e.g., W3C verifiable credentials, Decentralized identifiers) that let employers automatically verify diplomas and certificates against authoritative registries (Sedlmeir et al., 2021). Robust verification protocols, backed by recognized accreditation bodies and standardized digital signatures, secure the chain of trust and reduce legal risk for all parties. Lastly, Qualified electronic signatures and compliant digital signatures decrease legal risk further: such a certificate is as legally binding as a notarized paper document signed by a public notary (Kask, 2024). Coupled with a full audit trail on the blockchain, such a design offers an unrefutable chain of evidence concerning the source, alteration, and utilization of each credential. This guarantees complete adherence to national and international regulations, reducing the risk of professional qualification disputes over authenticity or ownership.

3.5. Standards and Interoperability

To ensure there is a trusted exchange and validation of digital credentials within the HR market, it is necessary to begin with standards that are generally accepted. The most popular are W3C verifiable credentials (VC) and Decentralized identifiers (DID), specifying the format, semantics, and crypto protocols for certificate and diploma issuing, exchange, and verification (Mazzocca et al., 2025). In the European context, the EBSI is creating mutual recognition schemes for digital IDs and qualifications across the member states based on OpenID Connect and OAuth2 as the access key to standardized user authentication and authorization. Interoperability between various ATS, HRIS, and blockchain platforms is enabled by open APIs and plug-and-play adapters with REST protocols, coupled with data schema mapping of candidate information (Elgebli, 2024). Through shared data models such as HR-XML or JSON-LD pro-

files, heterogeneous systems can map fields such as "workExperience" or "certificationDate" without loss of semantic meaning. Federated models, such as consortium models, where every organization has its own ledger, allow consensus on shared rules and access policy without central control (Opalek, 2021). But implementing these standards and protocols is a strong technical and organizational task. Technically, blockchain technologies should be low-latency and high-throughput for big data storage and verification, and good solutions for off-chain scaling. Organationally, there typically are not enough blockchain and semantic web experts, opposition to adapting existing HR practices, and compatibility problems with national digital-identity policies. Success hinges on industries teaming up to agree on common standards, run training and pilot projects, and set clear, straightforward rules for data protection and access (Qi et al., 2021).

4. Conclusion

This study proposed an integrated AI–blockchain e-recruitment ecosystem, emphasizing the synergy of automation and trust. Competency passports empower candidates to control their verified credentials while reducing fraud and inefficiencies for employers (Mazharunnisa et al., 2024). Our model highlights how AI enhances decision-making with data-driven insights and how blockchain creates verifiable, portable records, resulting in faster, more equitable hiring processes. Key contributions include a structured model clarifying stakeholder roles and technological layers, and insights into mitigating recruitment pain points. However, adoption faces barriers such as regulatory uncertainty, scalability concerns, and resistance to change. Legal frameworks must evolve to support blockchain-based credentials, and standards are essential for interoperability. As a conceptual study, our findings call for empirical testing to confirm their applicability. In summary, our research offers a blueprint for more efficient, secure, and fair hiring practices while acknowledging the challenges ahead.

5. Future Work

To bring this vision to fruition, future work should address the following areas:

1. **Prototype development and testing**: Building and piloting a functional system combining blockchain-based competency passports with AI-driven workflows. This would enable measurement of hiring speed, accuracy, and user satisfaction against traditional benchmarks (Das, 2024). Usability feedback from both recruiters and applicants would refine the design.
2. **User adoption studies**: Investigating how recruiters and candidates perceive and use these tools across different cultural and organizational contexts (Suktam et al., 2024). Understanding trust, transparency expectations, and willingness to engage with digital credentials is crucial for a successful rollout.
3. **Technical enhancements**: Research should focus on ensuring scalability and improving integration with legacy HR systems. AI algorithms must continue to improve in fairness and explainability to build trust and com-

ply with ethical standards (Chen, 2023). Bias mitigation techniques and audit frameworks should accompany deployment.

4. **Governance and policy**: Defining legal frameworks and international standards for blockchain-based credentials and competency passports is vital (EBSI, 2025). Privacy-preserving techniques such as zero-knowledge proofs could support compliance with data protection laws while maintaining security and trust.

By addressing these areas, future research can help transform our conceptual model into a robust, trustworthy, and globally accepted e-recruitment ecosystem.

Funding: This research was funded by [The Ministry of Education, Science and Technological Development] grant number [11158].

References

1. Abdullah, A. A., Khanom, M., Yusuf, A., & Tanko, M. (2024). UTILIZING BLOCKCHAIN AND SMART CONTRACTS TO ENHANCE TRANSPARENCY AND EFFICIENCY IN HUMAN RESOURCES MANAGEMENT PROCESSES: A CONCEPTUAL APPROACH. *iBAF E-Proceedings*, *11*(1), Article 1. https://doi.org/10.33102/6k548b68
2. Aleisa, M. A. A., Alshahrani, M. J. S., Beloff, N., & White, M. (2022). ***TAIRA-BSC - trusting AI in recruitment applications through blockchain smart contracts***. University of Sussex. https://doi.org/10.1109/Blockchain55522.2022.00059']
3. Aljuaid, A. (2021). ***AI based e-recruitment system*** [Thesis, Brunel University London]. http://bura.brunel.ac.uk/handle/2438/24663
4. Allal-Chérif, O., Yela Aránega, A., & Castaño Sánchez, R. (2021). Intelligent recruitment: How to identify, select, and retain talents from around the world using artificial intelligence. *Technological Forecasting and Social Change*, *169*, 120822. https://doi.org/10.1016/j.techfore.2021.120822
5. Anaam, E. A., Ghazal, T. M., Haw, S. C., Alzoubi, H. M., Alshurideh, M. T., & Al Mamun, A. S. (2023). ***Utilization of Blockchain Technology In Human Resource Management***. 1–5. https://doi.org/10.1109/ICAIC57335.2023.10044181
6. Anghel, D. (2023). New Perspectives for Human and Artificial Intelligence Interactions for Leadership e-Recruitment. *Societies*, *13*(3), Article 3. https://doi.org/10.3390/soc13030055
7. Bhatia, V., Rawat, P., Kumar, A., & Shah, R. R. (2019). ***End-to-End Resume Parsing and Finding Candidates for a Job Description using BERT*** (arXiv:1910.03089). arXiv. https://doi.org/10.48550/arXiv.1910.03089
8. Black, J. S., & van Esch, P. (2020). AI-enabled recruiting: What is it and how should a manager use it? *Business Horizons*, *63*(2), 215–226. https://doi.org/10.1016/j.bushor.2019.12.001
9. Bogdanović, Z., Radenković, B., Despotović-Zrakić, M., Barać, D., Labus, A., & Naumović, T. (2019). BLOKCHAIN TECHNOLOGIES: CURRENT STATE AND PERPECTIVES. *Zbornik Radova Međunarodne Naučne Konferencije o Digitalnoj Ekonomiji DIEC*, *2*(2), 1–12.
10. Bogen, M., & Rieke, A. (2018). Help wanted: An examination of hiring algorithms, equity, and bias. *Upturn, December*, *7*. https://www.voced.edu.au/content/ngv:92627
11. Bornstein, S. (2018). ***Antidiscriminatory Algorithms*** (SSRN Scholarly Paper 3307893). Social Science Research Network. https://papers.ssrn.com/abstract=3307893
12. Chen, Z. (2023). Ethics and discrimination in artificial intelligence-enabled recruitment practices. *Humanities and Social Sciences Communications*, *10*(1), 567. https://doi.org/10.1057/s41599-023-02079-x
13. Council of Europe. (2000). ***Definitions—European Youth Foundation—Www.coe.int***. European Youth Foundation. https://www.coe.int/en/web/european-youth-foundation/definitions
14. Das, S. (2024, October 26). Blockchain Technology: The Future Of Credentialing In eLearning. *eLearning Industry*. https://elearningindustry.com/blockchain-technology-the-future-of-credentialing-in-elearning

15. de Alwis, A., Shrestha, A., & Sarker, T. (2025). Exploring Governance for accreditation in the education sector using blockchain technology: A systematic literature review. ***Discover Education***, ***4***(1), 57. https://doi.org/10.1007/s44217-025-00449-y
16. Dillahunt, T. R., Israni, A., Lu, A. J., Cai, M., & Hsiao, J. C.-Y. (2021). Examining the Use of Online Platforms for Employment: A Survey of U.S. Job Seekers. ***Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems***, 1–23. https://doi.org/10.1145/3411764.3445350
17. EBSI. (2015). ***Formal Accreditation and Recognition***. Facilitating the Issuance, Recognition, and Acceptance of Digital Student University Certificates to Enable Their Cross-Border Use. https://ec.europa.eu/digital-building-blocks/sites/display/EBSI/Formal%2BAccreditation%2Band%2BRecognition
18. EBSI. (2025). ***The first public sector blockchain infrastructure in Europe***. Experience Cross-Border Services with EBSI. https://ec.europa.eu/digital-building-blocks/sites/display/EBSI
19. Elgebli, J. (2024). ***BTM standards integration within talent management processes: An ontology engineering approach*** [Other, Université du Québec en Outaouais]. https://di.uqo.ca/id/eprint/1727/
20. English, L. M., & Carlsen, A. (2019). Lifelong learning and the Sustainable Development Goals (SDGs): Probing the implications and the effects. ***International Review of Education***, ***65***(2), 205–211. https://doi.org/10.1007/s11159-019-09773-6
21. Enis Dorlevi. (2024, April 16). The Use Cases Of Blockchain-based Digital Credentials. ***SertifierBlog***. https://sertifier.com/blog/blockchain-based-digital-credentials/
22. Idris, I. (2025). Utilization of Blockchain Technology in Talent Management: Increasing Transparency and Security of the Employee Recruitment Process. ***Journal of Information Systems Engineering and Management***, ***10***(5s), Article 5s. https://doi.org/10.52783/jisem.v10i5s.630
23. Jirgensons, M., & Kapenieks, J. (2018). Blockchain and the Future of Digital Learning Credential Assessment and Management. ***Journal of Teacher Education for Sustainability***, ***20***(1), 145–156. https://doi.org/10.2478/jtes-2018-0009
24. Kandpal, B. C., Sharma, D., Pandey, S., Gehlot, A., Sudhanshu, S., & Duggal, A. S. (2023). Automated Intervention of Blockchain in Human Resource Management. ***2023 International Conference on Disruptive Technologies (ICDT)***, 609–612. https://ieeexplore.ieee.org/abstract/document/10150995/
25. Kask, L. (2024). Time of Signing: Legal Requirements and Technical Options for Hand-written and Electronic Signatures. ***Juridica International***, ***33***, 62–76. https://doi.org/10.12697/JI.2024.33.05
26. Kim, T. H., Kumar, G., Saha, R., Rai, M. K., Buchanan, W. J., Thomas, R., & Alazab, M. (2020). A privacy preserving distributed ledger framework for global human resource record management: The blockchain aspect. ***IEEE Access***, ***8***(9095290), 96455–96467. https://doi.org/10.1109/ACCESS.2020.2995481
27. Kişi, N. (2022). Exploratory Research on the Use of Blockchain Technology in Recruitment. ***Sustainability***, ***14***(16), Article 16. https://doi.org/10.3390/su141610098
28. Koman, G., Toman, D., Jankal, R., & Boršoš, P. (2024). The Importance of e-Recruitment within a Smart Government Framework. ***Systems***, ***12***(3), Article 3. https://doi.org/10.3390/systems12030071
29. Koncheva, V. A., Odintsov, S. V., & Khmelnitski, L. (2019). ***Blockchain in HR***. 504–507. https://doi.org/10.2991/iscde-19.2019.154
30. Kroll, E., Veit, S., & Ziegler, M. (2021). The Discriminatory Potential of Modern Recruitment Trends—A Mixed-Method Study From Germany. ***Frontiers in Psychology***, ***12***. https://doi.org/10.3389/fpsyg.2021.634376
31. Laal, M. (2011). Lifelong Learning: What does it Mean? ***Procedia - Social and Behavioral Sciences***, ***28***, 470–474. https://doi.org/10.1016/j.sbspro.2011.11.090
32. Leicht-Deobald, U., Busch, T., Schank, C., Weibel, A., Schafheitle, S., Wildhaber, I., & Kasper, G. (2019). The Challenges of Algorithm-Based HR Decision-Making for Personal Integrity. ***Journal of Business Ethics***, ***160***(2), 377–392. https://doi.org/10.1007/s10551-019-04204-w

33. Li, D., & Estacio, J. D. (2024). The Evolution of HRM: From Personnel Management to Strategic Partner. *Open Access Library Journal*, *11*(8), Article 8. https://doi.org/10.4236/oalib.1111928
34. Mazharunnisa, Md., P Y, N., Apoorva, K., Poojasri, Kalakanti., Jain, D., & Shalini, G. (2024). Blockchain In Human Resources: Ensuring Data Privacy And Transparency In Employee Management. *2024 2nd International Conference on Disruptive Technologies (ICDT)*, 90–95. https://doi.org/10.1109/ICDT61202.2024.10488946
35. Mazzocca, C., Acar, A., Uluagac, S., Montanari, R., Bellavista, P., & Conti, M. (2025). A Survey on Decentralized Identifiers and Verifiable Credentials. *IEEE Communications Surveys & Tutorials*, 1–1. https://doi.org/10.1109/COMST.2025.3543197
36. Milovanović, S., Bogdanović, Z., Labus, A., Despotović-Zrakić, M., & Mitrović, S. (2022). Social recruiting: An application of social network analysis for preselection of candidates. *Data Technologies and Applications*, *56*(4), 536–557. https://doi.org/10.1108/DTA-01-2021-0021
37. Mishra, H., & Venkatesan, M. (2021). Blockchain in human resource management of organizations: An empirical assessment to gauge HR and non-HR perspective. *Journal of Organizational Change Management*, *34*(2), 525–542. https://doi.org/10.1108/JOCM-08-2020-0261
38. MIT. (2017, October 17). *Digital Diploma debuts at MIT*. MIT News | Massachusetts Institute of Technology. https://news.mit.edu/2017/mit-debuts-secure-digital-diploma-using-bitcoin-blockchain-technology-1017
39. Nocker, M., & Sena, V. (2019). Big Data and Human Resources Management: The Rise of Talent Analytics. *Social Sciences*, *8*(10), 1–19.
40. Odun-Ayo Isaac, Misra Sanjay, Omoregbe Nicholas, Onibere Emmanuel, Bulama Yusuf, & Damasevičius Robertast. (2017). *Cloud-Based Security Driven Human Resource Management System*. https://doi.org/10.3233/978-1-61499-773-3-96
41. Okolie, U. C., & Irabor, I. E. (2017). E-Recruitment: Practices, Opportunities and Challenges. *European Journal of Business and Management*, *9*(11), 116–122.
42. Opalek, A. (2021). Data element mapping to analyze fit for use of three XML standards for health workforce tracking. *Human Resources for Health*, *19*(1), 72. https://doi.org/10.1186/s12960-021-00615-x
43. Peisl, T., & Shah, B. (2019). The Impact of Blockchain Technologies on Recruitment Influencing the Employee Lifecycle. In A. Walker, R. V. O'Connor, & R. Messnarz (Eds.), *Systems, Software and Services Process Improvement* (pp. 695–705). Springer International Publishing. https://doi.org/10.1007/978-3-030-28005-5_54
44. Qi, J., Chen, X., Jiang, Y., Jiang, J., Shen, T., Zhao, S., Wang, S., Zhang, G., Chen, L., Au, M. H., & Cui, H. (2021). Bidl: A High-throughput, Low-latency Permissioned Blockchain Framework for Datacenter Networks. *Proceedings of the ACM SIGOPS 28th Symposium on Operating Systems Principles*, 18–34. https://doi.org/10.1145/3477132.3483574
45. Qin, C., Zhu, H., Xu, T., Zhu, C., Jiang, L., Chen, E., & Xiong, H. (2018). *Enhancing Person-Job Fit for Talent Recruitment: An Ability-aware Neural Network Approach*. 25–34. https://doi.org/10.1145/3209978.3210025
46. Raghavan, M., Barocas, S., Kleinberg, J., & Levy, K. (2020). Mitigating bias in algorithmic hiring: Evaluating claims and practices. *Proceedings of the 2020 Conference on Fairness, Accountability, and Transparency*, 469–481. https://doi.org/10.1145/3351095.3372828
47. Rozario, S. D., Venkatraman, S., & Abbas, A. (2019). Challenges in Recruitment and Selection Process: An Empirical Study. *Challenges*, *10*(2), Article 2. https://doi.org/10.3390/challe10020035
48. Satyabrata Das. (2024). *Blockchain Technology: The Future Of Credentialing In eLearning—eLearning Industry*. Blockchain Technology: The Future Of Credentialing In eLearning. https://elearningindustry.com/blockchain-technology-the-future-of-credentialing-in-elearning
49. Sedlmeir, J., Smethurst, R., Rieger, A., & Fridgen, G. (2021). Digital Identities and Verifiable Credentials. *Business & Information Systems Engineering*, *63*(5), 603–613. https://doi.org/10.1007/s12599-021-00722-y

50. Sharma, P., Bhattacharya, S., & Bhattacharya, S. (2025). HR analytics and AI adoption in IT sector: Reflections from practitioners. *Journal of Work-Applied Management*, *ahead-of-print*(ahead-of-print). https://doi.org/10.1108/JWAM-12-2024-0179
51. Sovtić, D., Trpkov, A., Radenković, M., Popović, S., & Labus, A. (2025). Examining Readiness to Buy Fashion Products Authenticated with Blockchain. *Journal of Theoretical and Applied Electronic Commerce Research*, *20*(2), Article 2. https://doi.org/10.3390/jtaer20020119
52. Suktam, W., Lapchit, S., Supsin, J., Sonwa, S., & Suthamdee, C. (2024). Blockchain in Education: Transforming Learning, Credentialing, and Academic Data Management. *Journal of Education and Learning Reviews*, *1*(6), Article 6. https://doi.org/10.60027/jelr.2024.739
53. Sven Kamieth. (2023). Blockchain Credentials – Marrying Education and HR. *Onchain*. https://onchain.org/magazine/blockchain-credentials-marrying-education-and-hr/
54. Tambe, P., Cappelli, P., & Yakubovich, V. (2019). Artificial Intelligence in Human Resources Management: Challenges and a Path Forward. *California Management Review*, *61*(4), 15–42. https://doi.org/10.1177/0008125619867910
55. Trpkov, A., Sovtić, D., Tomić, M., Labus, A., & Rodić, B. (2024). STAKEHOLDERS' READINESS FOR ADOPTING BLOCKCHAIN IN THE FASHION INDUSTRY. *Facta Universitatis, Series: Electronics and Energetics*, *37*(1), Article 1.
56. Ucha, B. D., Ajayi, F. A., & Olawale, O. (2024). Integrating blockchain in HR and finance: A conceptual review and future directions. *Open Access Research Journal of Multidisciplinary Studies*, *7*(2), 131–139. https://doi.org/10.53022/oarjms.2024.7.2.0034
57. UNESCO. (2020). *Non-formal education*. Non-Formal Education. https://uis.unesco.org/en/glossary-term/non-formal-education
58. VerifyEd. (2025). *What Are Blockchain Digital Credentials? An Expert Guide (2025)*. https://www.verifyed.io/blog/blockchain-digital-credentials
59. Zyskind, G., Nathan, O., & Pentland, A. "Sandy." (2015). Decentralizing Privacy: Using Blockchain to Protect Personal Data. *2015 IEEE Security and Privacy Workshops*, 180–184. https://doi.org/10.1109/SPW.2015.27

Pavle Jakovac, PhD[1] *Keynote paper*

THE DIGITAL EURO: A NEW ERA OF PUBLIC MONEY AND PRIVACY PROTECTION IN THE EUROZONE

Abstract

This research examines the development and implementation of the digital euro, a central bank digital currency (CBDC) for retail use, initiated by the European Central Bank (ECB). The primary aim is to analyze how the digital euro can enhance monetary sovereignty, improve the euro area's payment system, and ensure secure, accessible, and efficient digital payments, with a particular focus on user privacy protection. Since October 2023, the digital euro project has been in its preparation phase, expected to last until 2025, after which a decision on implementation may be made. One of the project's central challenges is safeguarding user privacy, as public consultations revealed significant concerns regarding transaction surveillance. In response, the ECB is developing a "privacy-by-design" approach, particularly for low-value transactions. Offline payment functionality is being considered, allowing digital euro use without an internet connection or sharing personal data with intermediaries or the ECB. This would provide privacy levels for small payments comparable to cash, while still complying with anti-money laundering and counter-terrorism financing regulations. The digital euro is likely to operate via a hybrid (two-tier) model: the ECB issues the currency, while commercial banks and fintechs(s) provide user services. The digital euro will be built on a hybrid infrastructure combining centralized issuance and control by the ECB with decentralized components handled by intermediaries. The system will be modular, interoperable, and designed with high data protection standards. The digital euro has the potential to strengthen monetary sovereignty and offer a public alternative to private digital currencies. Its success will depend on public trust, requiring a clear regulatory framework, stakeholder engagement, and transparency in both technical and legal system design.

Key words: *Digital Euro, Central Bank Digital Currency (CBDC), Privacy, Payment System, Monetary Sovereignty.*

1 Associate professor, University of Rijeka, Faculty of Economics and Business, Rijeka, Croatia
pavle.jakovac@efri.uniri.hr

1. Introduction

Over the past decades, globalization and the rapid adoption of digital technologies have profoundly changed the way individuals and businesses conduct financial transactions and payments. Traditional forms of cash are increasingly absent from everyday life, while credit and debit cards - combined with contactless payment technologies - have become ever more popular, frequently replacing cash as the primary means of payment. The COVID-19 pandemic has further accelerated this digitalization trend, as restrictions on physical contact and social distancing measures prompted both consumers and businesses to adopt electronic and wireless payment methods more widely. Simultaneously, a growing share of the global population has embraced digital payment instruments, including cryptocurrencies, which has further steered the transition towards a cashless, digital economy. This transformation is driving money - the cornerstone of any financial system - to progressively assume a digital form, with digital currency becoming an official, recognized, and regulated means of payment.

These changes offer numerous advantages: they speed up transactions, reduce costs, and broaden access to financial services for a wider population - including those who were previously excluded from the formal financial system. Nevertheless, the digitalization of money and payments introduces a range of new challenges and risks. Among the most pressing issues are data security, privacy protection, the prevention of misuse, and the need to preserve the stability of the financial system. Against this backdrop, central banks globally have recognized the necessity for adaptation and innovation, launching the development of their own official digital currencies, known as central bank digital currencies (CBDCs). The most prominent European example is the digital euro - a planned, secure, digital version of cash aimed at being accessible to both citizens and businesses, while at the same time safeguarding the sovereignty and control that central banks exert over the monetary system. Comparing the digital euro to cryptocurrencies is essential for understanding its role and legal status. Unlike cryptocurrencies, the digital euro would represent legal tender, with its development and issuance entirely under the control and supervision of relevant institutions - primarily the European Central Bank (ECB).

Cryptocurrencies, while often utilizing similar distributed technologies, are not recognized or regulated as official currencies; rather, they are decentralized digital instruments whose use frequently eludes oversight by financial regulators. As such, the digital euro is designed to meet the challenges posed by new technologies and trends, while retaining the core functions of money within the monetary system - as a medium of exchange, unit of account, and store of value. A crucial challenge in the design of the digital euro is ensuring a high degree of privacy and anonymity in financial transactions - an aspect that, according to surveys, ranks among the most important criteria for European citizens considering digital money. Central banks must strike a careful balance between protecting user privacy and meeting regulatory requirements for transparency, especially to prevent money laundering and the financing of terrorism. In this context, the digital euro may rely on models that combine account-based and

token-based functionalities, with the aim of providing straightforward, secure use in accordance with legal frameworks and technological standards. This hybrid approach also facilitates interoperability with existing payment systems and ensures the scalability required across European Union member states.

All these considerations make clear that developing the digital euro is not merely a technical undertaking - it also encompasses significant economic, legal, and societal aspects. The digitalization of money is set to fundamentally alter how individuals, companies, and institutions manage their finances, with the potential for greater financial inclusion and enhanced modernization of payment systems. Given the complexity, it is expected that the key elements of the digital euro's design and architecture will be defined by the end of 2025, after which decisions regarding its implementation will follow. This process involves reconciling regulatory requirements with user needs, integrating new technologies, and ensuring the long-term financial stability of the euro area.

The development of the digital euro is closely watched by both experts and the wider public, as it is anticipated to have significant implications for the future shape of the global financial system especially when it is known that one of the motivations behind the digital euro is also geopolitical in nature. The European Union (EU) is seeking to reduce its dependence on American technological and financial infrastructures and to maintain monetary autonomy in the digital age. Additionally, the ECB views the digital euro as a tool to strengthen pan-European integration and resilience in the face of potential disruptions in payment systems (de Manuel, 2024). Therefore, the purpose of this paper is to become familiar with concept of digital euro especially it's current situation. This paper is divided into five parts. After the introductory remarks follows the section on the concept of central bank digital currency and differences compared to cryptocurrencies. The third part provides an overview regarding the model(s) and design of the digital euro. The fourth part presents the architecture of the digital euro and final solution(s) while main research findings and final remarks ae presented in the last part of the paper.

2. The Concept of Central Bank Digital Currency (CBDC) and Differences Compared to Cryptocurrencies

Like other central banks, the European Central Bank (ECB) conducts monetary policy and ensures the stability of the financial system, including the payment system. Central banks achieve this by providing central bank money, which underpins transactions for both the business sector and the public. Central bank money serves as a means of payment, a unit of account, and a store of value. Banks provide it to the public in the form of cash, and to banks and financial institutions through reserve and settlement accounts (Petrović, 2022; Nikolić and Pečarić, 2012). Money as a means of payment is divided into central bank money and private money. Central bank (or public) money can exist in physical form (cash) or in digital form (reserves), the latter being available only to commercial banks. Most of the money available to the public exists as private money created by banks through lending, although central bank money in the form of cash

is also accessible to the public. The value of private money is maintained by its convertibility into central bank money. Private money is created by commercial banks when they grant loans, appearing as balances in bank statements and savings accounts, and is used for card payments or online payment services. Withdrawing cash from an ATM converts private money into central bank money, and depositing cash into a bank account converts central bank money into private money. Private money retains its value because the public trusts it can be converted into central bank money, for example when withdrawing cash or settling interbank payments (ECB, 2020; ECB, 2021; ECB, 2022).

2.1. Central Bank Digital Currency (CBDC)

A Central Bank Digital Currency (CBDC) is a digital form of public money issued by the central bank. It consists of a digital representation of coins and banknotes in the form of digital or physical tokens. It is an electronic file that embodies a certain value with a reference to its owner. Changing this reference transfers value and completes a payment. Central banks present CBDC as a supplement to cash (on the liabilities side of the central bank's balance sheet) that retains the characteristics of cash but is adapted to the functional needs enabled by digital technology. The CBDC system consists of individuals and companies with access to digital currency for transactions and savings accounts held at the central bank in their country. There are two types: retail CBDC (available to all citizens and legal entities) and wholesale CBDC (available only to financial institutions). CBDC is being introduced in response to new payment habits among citizens, aiming to make public money available in electronic form - giving central bank money a digital dimension and transforming it into central bank digital money guaranteed by the central bank. CBDC is a digital currency of the central bank, meaning it has legal tender status because it is issued by the central bank, which distinguishes it from other forms of crypto assets. It must be accepted if offered in a given country, whereas other electronic means of payment can be refused. If payment were made in a type of crypto asset, the creditor would not be obliged to accept it. It is important to distinguish between a scenario where all cash is replaced by digital money and one where digital money (e.g., the euro) is only a supplement to cash on the central bank's balance sheet and thus exchangeable for cash. The latter model is what the ECB intends to implement in practice, involving the participation of banks.

The main advantages of CBDC are security, efficiency, lower costs, and discretion. Its purpose is to serve as a means of payment, a unit of account, and a store of value. All parties involved in a transaction will have the direct right to request the central bank to issue CBDC, even when transactions are intermediated by commercial banks. This distinguishes CBDC from cash, as in the event of a bank failure, citizens could lose money deposited in a bank account, but CBDC cannot be lost due to its low solvency risk. CBDC emerged as a response to digitalization and the development of information technologies that increase demand for digital transactions. It is a new type of fiat money available to the public, which was not previously the case, as digital central bank money was only available to credit institutions, banks, and Financial Market Infrastructure

(FMI) system institutions. CBDC combines the features of a digital deposit and peer-to-peer transactions, with four main characteristics: electronic form, central bank money, peer-to-peer capability, and broad accessibility (Skrbin, 2021).

2.2. Differences Between CBDC and Crypto Assets

Experts highlight that the main difference between CBDC and crypto assets is that crypto assets are speculative, while CBDC is a supplement to cash and can mitigate the shortcomings of crypto assets. Unlike cryptocurrencies, CBDC fulfils all the characteristics of money, is centralized, serves as a currency, and is issued by the central bank. Thus, CBDC is digital money equivalent to cash - digital cash issued by the central bank, which is also responsible for maintaining the value of the official currency, including CBDC, which is simply the digital form of the official currency available to citizens and the business sector, not just banks as with reserves (Grgurević., 2022; ECB, 2020; EDPS, 2023). Crypto assets are issued by private actors, with nearly 22,000 different types, and are based on blockchain technology - a distributed ledger operated by a network of computers (Frankenfield, 2022a; Androutsellis-Theotokis and Spinellis, 2004). Unlike CBDC, bitcoin and other crypto assets are not money in the true sense, as they do not fulfil all the functions of money. No central bank will call crypto assets like bitcoin money or currency, as they do not meet all the functions of money, are not supervised or issued by a central bank, and are inventions of private companies. They are highly volatile because there is no institution maintaining their value. Central banks see such payment instruments as competitors that offer a high level of data protection and privacy, but are very risky for investment. Their high level of anonymity is both their greatest advantage and their greatest weakness, as it enables the financing of terrorism, money laundering, and other criminal activities. Unlike CBDC, crypto assets have no physical form, meaning they cannot be converted into cash once cash is exchanged for crypto assets (Petrović, 2022; EDPS, 2023).

According to the ECB, crypto assets are not money but digital tokens that can be exchanged electronically and are created by computer networks using complex mathematical formulas that no one supervises. Because they have no physical equivalent, they have no intrinsic value. Very few exchanges accept, for example, bitcoin in exchange for real money; it usually must be exchanged for another type of crypto asset with higher demand. Crypto assets that can be exchanged for real money are usually denominated in dollars. Many support their use due to liquidity, low transaction costs, transaction speed, and micro-payments. Their advantage is decentralization, as no institution can influence the amount of bitcoin issued or inflation. They are governed solely by a protocol based on cryptography and open-source code (Tomašić, 2017; Skrbin, 2021). According to Tomašić (2017) and EDPS (2023), for digital currencies to be considered money, they must fulfill three functions: 1) unit of account (very few transactions are denominated in cryptocurrencies, and merchants avoid this due to high volatility); 2) medium of exchange (refers to the acceptance of cryptocurrencies as a means of payment - while the number and value of such transactions are increasing, they are still far from surpassing traditional

currencies); 3) store of value (the value of cryptocurrencies depends on user trust, predictable supply, and uncertain demand, making short-term investment in cryptocurrencies risky, especially as they are not subject to legal regulation).

Since bitcoin is not managed by any institution that would guarantee its value - a key criterion for the acceptance of any money - it cannot be considered money in the full sense. If money is physical, the issuer ensures its quality to prevent counterfeiting and abuse. If money is electronic (e.g., a bank deposit), appropriate security and maintenance measures are applied. In case of disputes, the issuer has the data needed to resolve the issue and can reverse transactions if necessary. The issuer is also legally responsible to users for safeguarding the value of their money and for any system losses. In the case of cryptocurrencies, no one is responsible for system errors or losses, and no one can reverse a transaction or identify users through collected data. Some issuer functions can be replaced by software, but a program cannot assume responsibility or provide legal protection in disputes, nor can it preserve the value of users' money. Since cryptocurrencies are not currencies, a creditor is not obliged to accept payment in cryptocurrency as settlement of a debt—this is only possible if both parties agree, and in case of breach, there is no legal protection (Tomašić, 2017).

2.3. Crypto Asset(s) as Competitor(s) to Cash

One of the main concerns of the ECB and central banks in general is that cash could quickly fall out of use if the trend of increasing use of crypto assets in payments continues. The main reason for the use of crypto assets is also their main advantage: a high level of protection for financial transaction data, personal data, and thus privacy. Sometimes the identity of the issuer of a cryptocurrency is known, sometimes not. Issuers can generate cryptocurrency units, which are then delivered to users who can resell them. Miners who provide computing power to validate transactions (also) create some cryptocurrency units.

Proponents of cryptocurrencies believe that loose monetary policy will lead to economic instability and expect cryptocurrencies to be accepted and integrated into fiat currencies. Their main advantages are anonymity and privacy, as they use pseudonyms not linked to personal data, but it is possible to review the source code and understand issuance mechanisms. In electronic money transactions offered by banks, user identities are collected. Electronic money is usually closed-source, meaning authorities can freeze accounts and reverse transactions, which is problematic for citizens in autocratic regimes. Records of cryptocurrency transactions are stored worldwide, making international cooperation to obtain such information impractical (Skrbin, 2021). Bitcoin uses blockchain technology - a decentralized management system that eliminates commercial banks as intermediaries in financial transactions. If the system were centralized, a single computer would process all daily transactions in seconds, and everyone would have to trust that computer not to tamper with the ledger or change the issuance rate or data security. Bitcoin relies on a decentralized user network with proof-of-work verification. Transactions are conducted using a public key for encryption and a private key for decryption. Bitcoin

can be sold on exchanges or earned as a reward for mining services and investments in equipment and energy. All types of crypto assets are electronic records of value stored in digital wallets on websites offering such services (Petrović, 2022).

The ECB aims to address this issue by offering citizens the option to pay with an official digital currency - legal tender that should, in terms of privacy and data protection, compete with crypto assets if the goal is to attract users. This is important to achieve key objectives: strengthening the euro internationally, preserving the central bank's monetary sovereignty, and providing a reliable and secure currency that is not volatile or prone to loss of value. For the digital euro to be widely accepted, it must be easy to use, affordable, enable fast transactions, be integrated into existing systems, increase financial inclusion, provide financial stability in crises, and ensure consumer protection. According to ECB research and public consultations, privacy protection is the most important factor. The ECB is acutely aware that achieving these positive effects depends on the level of privacy protection. If privacy is insufficient, citizens may refuse to use the digital euro. Therefore, the digital euro must offer the highest level of privacy protection, allowing users to choose how much and which information they wish to disclose, in accordance with legal requirements (de Manuel, 2024).

3. Models and Design of the Digital Euro: A Short Theoretical (and Technical) Overview

The digital euro is a digital currency issued by the ECB, classified as a CBDC. It represents an electronic payment and transaction system currently in its preparatory phase, expected to conclude by the end of 2025. The digital euro would serve as an alternative to commercial bank deposits. It would be universally accessible, free of charge, and compliant with privacy requirements. Rather than replacing cash, it would exist as its digital counterpart. This means that citizens, instead of depositing all their funds in banks, could hold part of their money in the form of digital euros. The digital euro is envisioned as a payment system that offers a universally accessible and secure electronic form of public money, providing individuals with a real alternative to commercial bank money. It would ensure that the Eurozone continues to provide public money to EU citizens, instead of allowing private companies to dominate the EU's monetary system. The goal is to make the digital euro as similar to cash as possible. The potential benefits of introducing the digital euro include: a) reducing reliance on profit-driven banks and enhancing financial system stability by offering people safe and resilient public money without credit risk, as central banks cannot go bankrupt; b) improving financial inclusion by involving a broader range of intermediaries to provide digital euro services, including non-profit and public entities such as public banks, postal networks, local governments, and even national central banks - unlike today's landscape dominated by selective commercial banks; c) promoting a more ethically responsible banking system by giving citizens greater autonomy in managing their own money; d) equipping the ECB with direct tools for conducting monetary policy, such as transferring interest rate changes directly to digital euro accounts or distributing money directly to people (so-called "helicopter money").

Coins and banknotes represent a valuable public service that is increasingly at risk due to the widespread use of contactless cards, mobile applications, cryptocurrencies, and the closure of many bank branches and ATMs. Today, most people rely on private money, which is more suitable for holding large amounts and conducting high-value transactions, in addition to being usable for digital payments.

3.1. Models of the Digital Euro

3.1.1. Centralized System

The centralized model of the digital euro assumes that the central bank, specifically the European Central Bank (ECB), plays a key role in issuing and managing the digital euro. All accounts and transactions are maintained within the Eurosystem infrastructure. There are two main variants within this model: the direct and the intermediary approach (ECB, 2020; Belačić, 2021). In the direct approach, end users open accounts directly with the central bank, which processes all transactions in real time. Private keys for digital signatures are stored with the users, and transactions are sent directly to the ECB. The main advantage of this model is the complete control and oversight by the ECB, as well as high transparency. However, this approach presents challenges such as significant operational workload for the central bank, technical limitations, and security requirements. The intermediary approach entails that users initiate payments through intermediaries (such as commercial banks), who hold accounts with the ECB on behalf of their clients. The ECB cooperates only with authorized intermediaries, which reduces the number of direct connections to the system and fosters competition among service providers. The challenges here include limited flexibility for end users and the need for reliable supervision of intermediaries. The technological framework of the centralized system is based on conventional databases under the full control of the ECB. This setup allows for faster data processing compared to DLT (Distributed Ledger Technology[1], but requires greater operational resources (Cheng, 2023).

3.1.2. Decentralized System

The decentralized model enables end users or their intermediaries to validate each payment without the need for centralized authorization. There are two types within this model: direct user access and the hybrid decentralized model (ECB, 2023). Direct user access allows the transfer of digital euros between users without intermediaries, based on DLT technology or local storage (cards, mobile devices), including offline payments. The advantages of this model are greater privacy and faster transactions. However, challenges include difficulties in complying with AML/CFT (Anti-Money Laundering/Countering the Financing of Terrorism)2, standards, security risks, and less control over the system. The hybrid decentralized model involves intermediaries in the settlement of

1 DLT (Distributed Ledger Technology): A technology for distributed ledgers, where transaction records are stored across a network of computers rather than in a single, central location. All network participants can read and add data, ensuring transparency and system resilience.

2 AML/CFT (Anti-Money Laundering/Countering the Financing of Terrorism): Regulations and standards intended to prevent money laundering and the financing of terrorism, requiring financial service providers to report suspicious activities and verify user identities.

transactions, but users retain a direct claim on the ECB. Intermediaries act as settlement agents and use the same infrastructure for both retail and wholesale payments. This approach combines the flexibility of decentralization with a certain level of ECB oversight. Challenges include the need for standardized cryptography and security protocols, as well as the modernization of intermediary systems. DLT technology enables decentralized storage and processing of transactions but brings challenges in terms of security, regulation, and alignment with monetary policy. Examples of implementations of such models include China, Brazil, Cambodia, and Ukraine (Cheng, 2023).

3.1.3. Hybrid System

The hybrid model combines elements of both centralized and decentralized approaches. Clients may have accounts with the central bank (centralized element), while transactions and user identity are managed by intermediaries (decentralized element). In this model, the user accesses the CBDC through an intermediary (bank, e-money provider, payment service provider-PSP), but holds a direct claim on the ECB. The central bank issues the digital euro and maintains stability, while intermediaries verify user identities and manage user interfaces. Advantages of the hybrid model include its similarity to the existing banking system, retention of responsibility and oversight of the issuance and design of the digital euro by the central bank, and the facilitation of innovation and competition through intermediaries. Challenges involve the need for clear data protection and identity regulations, balancing user privacy with regulatory requirements, and the complexity of integrating various technological solutions (Rayan, 2022; EDPS, 2023).

Table 1. Comparative Overview of Models

Model	Key Actors	Technology	Advantages	Challenges
Centralized	ECB, intermediaries	Centralized databases	Full control, transparency	Operational workload, scalability
Decentralized	Users, intermediaries	DLT, local storage	Privacy, speed	Security, AML/CFT, regulation
Hybrid	ECB, intermediaries	Combined	Balance of control and innovation	Complexity, regulation, integration

Source: Author's compilation based on ECB (2020; 2021; 2022), Belačić (2021), Cheng (2023), ECB (2023), Rayan (2022), and EDPS (2023)

All three models of the digital euro have specific advantages and challenges. The centralized model ensures the highest level of oversight and transparency

but requires significant operational resources and faces scalability risks. The decentralized model offers greater privacy and speed but encounters challenges related to security, compliance with AML/CFT standards, and regulatory issues. The hybrid model seeks to combine the best of both approaches, aligning with current banking practices and enabling innovation through intermediaries, but it requires carefully defined regulations and technical integration.

3.2. Design of the Digital Euro

Hardware solutions would be embedded in devices such as mobile phones, computers, smart cards, or tokens, which end users could utilize to access digital euro services through mobile or internet banking applications and to initiate POS[1] or P2P[2] payments. So far, banks have developed two approaches for accessing the CBDC. The transfer mechanism could function either through an account-based system or as a bearer instrument (token-based model) (ECB, 2023).

3.2.1. Token-based Digital Euro

One of the most discussed design choices for the digital euro is the token-based model, conceptualized as the digital equivalent of cash. In this model, users hold digital "tokens" that represent value and can transfer them directly to others without centralized account management. If a bearer-instrument approach is used, both payer and payee are responsible for verifying the transfer - just as with physical cash. Such a system does not rely on identity verification, especially for small-value payments, thereby enabling pseudonymous access and use. In this architecture, the digital euro is not directly monitored by the Eurosystem or supervised intermediaries. As a result, authorities cannot control whether users exceed holding limits, conduct large cross-border transactions, or bypass restrictions for specific user groups. Instead, control would be embedded in the user's payment device - such as a smartphone, smart card, or other hardware wallet - which introduces the need to protect sensitive identity-related data. According to the ECB (2023), these devices would connect through banking apps or internet platforms to initiate POS or P2P payments, while also supporting offline functionality. This model protects privacy by design. Through the use of cryptographic keys and digital signatures, transactions are authorized without requiring the user's identity to be revealed. However, users must securely manage their private keys; loss of this information results in a permanent loss of access to their funds (Collet et al., 2020). Despite the high level of privacy, central banks and designated authorities retain the right to access and share transaction data with third parties when legally justified. The level of anonymity thus varies across jurisdictions. For example, in China's CBDC model, the central bank is allowed to share financial transaction data with third parties under specific legal conditions (Cheng, 2023).

1 POS (Point of Sale): Refers to the place or device where a sales transaction occurs, such as terminals in stores where customers make payments using cards or other means.

2 P2P (Peer-to-Peer): Refers to direct payment between two individuals, without intermediaries, for example, when one person sends money to another using a mobile app like Revolut or mobile banking.

The advantages of the token-based CBDC model include strong privacy for small-value transactions, fast and inexpensive transfers (including offline capabilities), reduced reliance on centralized databases and intermediaries, greater financial inclusion by providing access to public money without requiring a traditional bank account. However, this model also poses challenges such as increased risk of money laundering and terrorist financing (AML/CFT),greater exposure to the loss of funds (e.g., from lost devices or stolen keys), more complex safeguards needed to prevent double-spending or fraud.

In sum, a token-based digital euro would offer high levels of privacy and emulate the properties of cash, potentially boosting public trust and adoption. Yet, its implementation must carefully balance the benefits of anonymity with regulatory compliance and security (de Manuel, 2024).

3.2.2. Account-based Digital Euro

The account-based model of the digital euro functions similarly to traditional banking systems, where each user holds an account with an authorized financial intermediary - such as a commercial bank or a licensed payment service provider. All transactions are recorded and processed through these accounts, enabling transparency and traceability across the payment system. In this model, users are required to verify their identity during account registration and for each transaction, in accordance with Know Your Customer (KYC) regulations. The transaction data is linked to users' identities and stored in centralized databases, often managed by intermediaries under the supervision of the European Central Bank (ECB) or national central banks. As such, the ECB would either maintain the ledger or oversee the intermediaries responsible for its upkeep (ECB, 2023; Cheng, 2023). This identity-linked model is exemplified by the Bahamian pilot project Sand Dollar, where account-based CBDC is used as a safeguard against illicit activities, including money laundering. In this system, a third party verifies the validity of transactions and updates the users' balances accordingly. However, such systems are limited by their dependency on continuous internet access. If the user or intermediary is offline, the transaction cannot be completed, highlighting the infrastructural constraints of real-time centralized verification (Collet et al., 2020). The operational flow within this model follows a structured sequence: a user initiates a payment, the interface verifies both the sender and the recipient, and the central bank processes the transaction by settling the account balances. The recipient is then notified of the completed payment through their respective interface.

Key advantages of the account-based model include enhanced monitoring and control of transactions, simplified integration with existing payment infrastructure, effective mechanisms for anti-money laundering (AML) and combating the financing of terrorism (CFT), possibility of refunding in cases of fraud or operational error. However, there are notable challenges and trade-offs such as the model's high dependency on user identification (thereby reducing transaction privacy and limiting anonymity), centralized databases become targets for cyber threats (raising concerns about data security), the Eurosystem must manage or supervise a large volume of user accounts (which may complicate scalability and operational resilience).

In summary, while the account-based digital euro offers robust regulatory advantages and operational familiarity, it raises significant concerns about privacy, user autonomy, and infrastructure complexity. These trade-offs must be carefully evaluated in parallel with token-based models to ensure that the digital euro remains a secure, accessible, and widely accepted public money instrument in the European Monetary Union (de Manuel, 2024).

4. Short Story Long – Analysis of the Architecture and Design of the Digital Euro: Is the Hybrid Model the (Best Final) Solution?

4.1 Architecture Analysis

One of the key questions surrounding the implementation of a CBDC is from whom should a CBDC system protect users' sensitive financial and personal data? This question requires careful consideration, especially in terms of legal, social, and risk-based perspectives. If the answer is that users are expected to place full trust in the central bank's ability to safeguard their privacy, then a centralized model emerges as the simplest and most cost-effective solution. However, a single breach of a centralized ledger or a related database containing sensitive user data could expose the financial transaction history and personal information of millions of individuals at once. For this reason, privacy advocates and proponents of cryptocurrencies tend to favour decentralized models, arguing that a centralized system entails a high level of trust and carries the risk of large-scale data leakage in the event of compromise.

A concerning issue with such centralized infrastructure is that the central bank may have access to an extensive amount of user data, which opens the door to potential mass surveillance or misuse by state authorities—for example, imposing sanctions or restrictions on account holders. Centralized digital architecture would make such interventions relatively cheap and easy to implement. The centralized data repository could also become a lucrative target for cybercriminals, highlighting once again the appeal of a decentralized approach, which is generally seen as offering more robust personal data protection (Belačić, 2021, p. 34-38). Moreover, the introduction of a digital euro could increase the surface area for cyberattacks, with major implications for monetary policy, financial stability, systemic risk, and the overall efficiency of the payment ecosystem. The aim of such attacks would typically be extortion, data theft, or economic disruption. Successful attacks could undermine public trust in the currency, hamper the usability of the digital euro, and violate confidentiality safeguards for users and their transactions. Therefore, the system would need to be highly resilient to cyber threats, capable of maintaining data integrity under attack, with very short recovery times and full protection of user data (ECB, 2020, p. 22-23; Belačić, 2021, p. 36).

While decentralized architecture performs better in terms of data protection, it falls short in areas that matter to both consumers and businesses. In such a model, commercial banks would be responsible for distributing the CBDC and processing retail payments. They would offer guarantees similar to cash by

managing a pool of central bank digital money, but citizens would no longer hold CBDC directly with the central bank. Instead, their claims would lie with intermediaries performing KYC procedures. As a result, the central bank would not maintain records of individual claims, nor would it be able to validate claims if a dispute arose. This model introduces supervisory and regulatory complications, as central banks would lack the data and insight needed to effectively address consumer protection requirements (Iredale, 2021; Kayrouz, 2021, p. 4-5).

A key feature of the hybrid CBDC architecture is the legal framework that ensures user claims are separate from the balance sheets of PSPs. This structure guarantees that if a PSP were to fail, user holdings of digital euro would not be treated as part of the PSP's assets subject to creditor claims. The legal framework must support bulk transfers and should grant the central bank the ability to reassign user holdings from one intermediary to another in the event of fraud, system failure, or technical breakdown. Unlike the direct model, the hybrid model allows user balances to be separated from PSPs' own finances, significantly enhancing user protection in the case of insolvency. For this reason, in the hybrid model, the central bank retains a copy of all retail CBDC holdings. While this model may be the most secure and functionally complete, it is also the most complex and expensive to implement (Iredale, 2021).

4.2 Design Analysis

In the case of implementing a CBDC in the form of tokens, digital money would share many characteristics with cash. Prepaid cards or applications similar to today's crypto-asset services could be used; however, CBDC applications would operate under regulatory oversight, unlike decentralized cryptocurrencies. Ownership would be based on possession of the key associated with each token, commonly referred to as a digital signature. Nevertheless, the system would most likely operate under managed infrastructure and would not be entirely anonymous as in the case of Bitcoin. A CBDC in the form of deposits held in accounts with the central bank would more closely resemble bank deposits. Ownership would be linked to a verified identity, and all transactions would be executed based on that identity.

According to the Bank for International Settlements (BIS), it is possible to combine both models. ECB is considering "tiered privacy," whereby small payments could allow for limited user identification, while larger transactions would be subject to full KYC and AML requirements. This does not imply a complete denial of access to user data by the ECB, but rather a technically and legally restricted access, supported by "privacy by design" solutions. Tokens, as a form of CBDC, could potentially facilitate illicit activities; therefore, emphasis is increasingly placed on account-based CBDC models.

However, the Bank Policy Institute (BPI) takes a different view, warning that an account-based model may reduce financial inclusion. Vulnerable users might face difficulties in accessing CBDC services due to burdensome KYC processes or account maintenance fees. As a result, BPI advocates for more accessible, digitally inclusive models, such as prepaid solutions or anonymous wallets

without permanent account registration. Bordo and Levin (2017) emphasize that in an account-based CBDC system, identity verification must be completed upon account creation. However, after that step, transactions can be executed swiftly and securely. The ECB would also be able to monitor suspicious transactions, thereby preventing illegal activities such as money laundering (Grgurević, 2022).

Unlike account-based CBDC, token-based CBDCs that enable anonymity, pseudonymity, and offline transactions pose specific challenges for AML/CFT efforts, as a user's identity can become obscured, making transaction tracking more difficult. For token-based models, CBDC systems would employ permissioned DLT infrastructures, where selected and supervised nodes carry out transaction validation. These tokenized designs that enable offline and peer-to-peer transactions resemble cash the most conceptually and can support a higher degree of privacy. However, full anonymity will not be permitted in CBDC systems (including in the euro area) due to binding AML/CFT obligations (Grothoff & Moser, 2021, str. 1-5).

Bindseil et al. (2024) advocate for combining account-based and token-based CBDC models. ECB is designing a two-tier architecture where the digital euro would resemble a secure, central bank-backed account instrument distributed via supervised intermediaries. While the application of interest rates is being considered, no final decision has been made (Grgurević, 2022, p. 30-33, 41; Gross, Klein & Sandner, 2020, p. 8-13). The token-based system consists of a wholesale interbank layer and a retail e-wallet layer, with a user interface accessible via smartphone for retail users. Only intermediaries that perform KYC procedures and manage user transactions can access information about the identity of token holders. This ensures that only verified users can access the CBDC system through an *ex-ante* identification process, with transaction histories retained among those actors. The central bank would not directly receive such data, which provides a layer of user privacy. In such a setup, users interact using a unique cryptographic alias as their transaction identity. It can thus be concluded that this model preserves user anonymity from validator infrastructure and other system participants by relying solely on pseudonymous public keys. Only selected intermediaries know the mapping between real user identities and public keys. All transactions are designed in such a way that only pseudonymous public keys are used without any inclusion of personal data (Grothoff & Moser, 2021, p. 1-5).

Since the start of the preparation phase (in October 2023), the ECB is finalizing the technical design, developing the legislative framework, and testing user solutions (de Manuel, 2024). Although it is not finally concluded (and depends on the results of pilot projects, regulatory decisions, and market feedback), the ECB and European institutions are aiming for a (hybrid) model that would combine the advantages of both approaches (i.e., token-based and account based model). For online transactions and larger amounts, the account-based model is preferred due to regulatory requirements and security, while tokenized models are being tested for small amounts and offline payments, as they enable greater privacy and ease of use. In terms of infrastructure (i.e., architecture),

the digital euro will be built on a hybrid infrastructure combining centralized issuance and control by the ECB with decentralized components handled by intermediaries. The system will be modular and designed with high data protection standards. The key factors are interoperability with existing payment systems and scalability.

In conclusion, it is expected that the digital euro, once introduced, will be designed to meet regulatory requirements as well as citizens' needs for privacy and ease of use, while preserving the financial stability of the Eurozone. It is expected that all key elements will be defined by the end of 2025, after which a decision on implementation could follow.

5. In Lieu of a Conclusion: Reflection(s) on the Future of the Digital Euro

In recent decades, financial markets have undergone a significant shift away from exclusive reliance on cash, driven by the rapid expansion of digital and online payment solutions. Today, numerous platforms offer services comparable to those of commercial banks, and both citizens and businesses - often unknowingly - allocate substantial funds to transaction fees. For example, two-thirds of all transactions in the Eurozone are processed via Mastercard and Visa, generating approximately €3 billion in fees annually for these companies, despite regulatory caps limiting fees to 0.3% of transaction value. Against this backdrop, the central banks of Eurozone member states, led by the ECB, are developing the digital euro - a digital version of cash intended for all Eurozone citizens. While the concept is not entirely new (with the Bahamas, Jamaica, Nigeria, China, and Brazil already having their own digital currencies), the ECB's initiative has the potential for a much broader reach. In some of these countries, the number of digital currency users is still small, while in China and Brazil, these models are available on a wider scale, though not yet universal.

Currently, the digital euro project is in the preparation phase, set to continue until the end of 2025. The initial research phase focused on design, while the current phase emphasizes implementation and solving practical challenges. The ECB envisions the digital euro as a free and non-profit instrument for citizens and businesses, adapted for offline payments, with funds held in accounts at the central bank rather than commercial banks. A key advantage is the possibility of directly transferring money to digital wallets of all households, thereby simplifying transactions and reducing the need for traditional instruments such as checks.

In a nutshell, the digital euro is envisioned as a retail CBDC, intended to be accessible to all citizens and businesses within the euro area, regardless of their banking affiliation. The proposed system is based on a two-tier model, in which the ECB issues the digital euro, while its distribution and user interaction are managed through authorized financial intermediaries. The system is designed to support both online and offline transactions, and it includes planned features that ensure a high level of privacy—at least for basic transactions—in order to address citizens' concerns (Bindseil et al., 2024). The strategic importance of the digital euro is also reflected in reducing dependence on global card com-

panies and strengthening the Eurozone's monetary sovereignty. Furthermore, cash today accounts for around 10% of GDP in most countries, with an even lower share in Scandinavia, illustrating the global trend of declining cash usage.

Despite its potential benefits, the introduction of the digital euro brings significant challenges. It is estimated that adapting the banking sector could cost between €18 and €30 billion (e.g., updating mobile banking apps, online platforms, card terminals, and ATM infrastructure). There are also legitimate concerns about the accessibility of the digital euro for all citizens, especially in Central and South-eastern Europe, where cash remains the dominant means of payment and digital literacy and ATM access are limited. The debate on the digital euro has been ongoing for four-five years, accompanied by various theories and controversies - from fears of state control over private finances to concerns about the abolition of cash. The experience of Scandinavian countries, where cash has almost disappeared from use, shows that payment digitalization can be rapid and comprehensive, while in other parts of Europe, cash remains irreplaceable.

Ultimately, the digital euro is increasingly emerging as an inevitable step in the digital transformation of the European payment system, with possible implementation by the end of this decade. It is crucial to emphasize that the digital euro will not replace or abolish cash and existing payment models, but will complement them, offering citizens and the economy additional security, flexibility, and competitiveness. The success of this initiative will depend on the ability of regulators, banks, and society to jointly address the challenges of inclusiveness, trust, and technological adaptation, thereby shaping the future of money in the Eurozone.

Acknowledgement

This research paper is part of the project uniri-iz-25-52: Globalization and the Future of Capitalism: Post-Capitalist Visions OR Can Capitalism Survive the Trend of De-/Re-Globalization and De-Growth?, funded by the European Union – NextGenerationEU.

Funded by the European Union
NextGenerationEU

"Funded by the European Union – NextGenerationEU. Views and opinions expressed are solely those of the author and do not necessarily reflect the official position of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.."

References

1. Androutsellis-Theotokis, S., Spinellis, D. (2004). A Survey of Peer-to-Peer Content Distribution Technologies. ACM Computing Surveys. 36(4). pp. 335-371.
2. Belačić, S. (2021). Digitalni euro. Sveučilište Jurja Dobrile u Puli, Fakultet ekonomije i turizma "Dr. Mijo Mirković", Pula. Available at https://dabar.srce.hr/islandora/object/unipu%3A6046. Accessed on September 6th, 2023.

3. Bindseil, U., Panetta, F. and Terol, I. (2024). The digital euro: Policy implications and implementation challenges. Review of International Political Economy. 31(1). pp. 122–146.
4. Bordo, D.M., Levin, T.A. (2017). Central Bank Digital Currency and the Future of Monetary Policy. National Bureau of economic research – NBER, Working Paper No. 23711, August 2017. Available at https://www.nber.org/papers/w23711. Accessed on Spetember 20th, 2023.
5. Cheng, P. (2023). Decoding the rise of Central Bank Digital Currency in China: designs, problems, and prospects. Journal of Banking Regulation. Vol. 24. pp. 156-170. Available https://doi.org/10.1057/s41261-022-00193-5. Accessed on July 25th, 2025.
6. Collet, L., Laurent, P., Eber, P., Martino, P., Messini, F., Havard, A., Sauvage, B., Pescatore, G. (2020). Are Central Bank Digital Currencies (CBDCs) the money of tomorrow? Available at https://www.deloitte.com/content/dam/assets-zone2/lu/en/docs/industries/financial-services/2023/lu-are-central-bank-digital-currencies.pdf. Accessed on September 4th, 2023.
7. de Manuel, M.E. (2024). From vision to reality: The digital euro in the making. ECB Occasional Paper Series. No. 2502. Amsterdam: De Nederlandsche Bank.
8. EDPS. (2023). Central bank digital currency. EDPS TechDispatch, Bruxelles. Available at https://edps.europa.eu/system/files/2023-03/23-03-29_techdispatch_cbdc_en.pdf. Accessed on September 15th, 2023.
9. European Central Bank – ECB. (2020). Report on a digital euro. Available at https://www.ecb.europa.eu/pub/pdf/other/Report_on_a_digital_euro~4d7268b458.en.pdf. Accessed on September 15th, 2023.
10. European Central Bank – ECB. (2021). Eurosystem report on the public consultation on a digital euro. Available at https://www.ecb.europa.eu/pub/pdf/other/Eurosystem_report_on_the_public_consultation_on_a_digital_euro~539fa8cd8d.en.pdf. Accessed on September 20th, 2023.
11. European Central Bank – ECB. (2022). The case for a digital euro: key objectives and design considerations. Available at https://www.ecb.europa.eu/pub/pdf/other/key_objectives_digital_euro~f11592d6fb.en.pdf. Accessed on September 15th, 2023.
12. European Central Bank – ECB. (2023). Opinion of the European Central Bank of October 31st, 2023 on the digital euro. Available at https://www.ecb.europa.eu/pub/pdf/legal/ecb.leg_con_2023_34.en.pdf. Accessed on July 25th, 2025.
13. Frankenfield, J. (2022). Cryptocurrency Explained With Pros and Cons for Investment. Available at https://www.investopedia.com/terms/c/cryptocurrency.asp. Accessed on July 22nd, 2022.
14. Gross, J., Klein, M., Sandner, G.P. (2020). The Digital Euro and the Role of DLT for Central Bank Digital Currencies. Frankfurt School Blockchain Center. Working Paper, May 2020. Available at https://www.researchgate.net/publication/341354711_The_Digital_Euro_and_the_Role_of_DLT_for_Central_Bank_Digital_Currencies. Accessed on September 6th, 2023.
15. Grothoff, C., Moser, T. (2021). How to issue a privacy-preserving central bank digital currency. SUERF Policy Briefs, No. 114, June 2021. Available at https://www.taler.net/papers/suerf2021en.pdf. Accessed on July 24th, 2025.
16. Grgurević, B. (2022). Izazovi monetarne politike uvođenjem digitalnog novca centralnih banaka. Sveučilište u Splitu, Ekonomski fakultet, Split. Available at https://repozitorij.efst.unist.hr/islandora/object/efst%3A4829. Accessed on September 6th, 2023.
17. Iredale, G. (2021). Central Bank Digital Currency: Know The Architecture Of Retail CBDC. Available at https://101blockchains.com/retail-cbdc-architecture/. Accessed on September 11th, 2023.
18. Kayrouz, P. (2021). Central Bank Digital Currencies and the Future of Money. Available at https://www.pwc.com/m1/en/media-centre/2021/documents/central-bank-digital-currencies-and-the-future-of-money-part1.pdf. Accessed on September 15th, 2023.
19. Nikolić, N., Pečarić, M. (2012). Uvod u financije. Sveučilište u Splitu, Ekonomski fakultet, Split.

20. Petrović I. (2022). Digitalne valute središnjih banaka - koncepti i primjeri. Sveučilište Josipa Jurja Strossmayera u Osijeku, Ekonomski fakultet, Osijek. Available at https://zir.nsk.hr/islandora/object/efos%3A5041/datastream/PDF/view. Accessed on July 26th, 2023.
21. Ryan, P. (2022). CBDC Hybrid Model. Available at https://www.linkedin.com/pulse/cbdc-hybrid-model-peter-ryan. Accessed on September 6th, 2023.
22. Skrbin, M. (2021). Svjetsko tržište kriptovaluta, Sveučilište u Zagrebu, Ekonomski fakultet, Zagreb. Available at https://zir.nsk.hr/islandora/object/efzg:7452/datastream/PDF/download. Accessed on July 26th, 2023.
23. Tomašić, M. (2017). Tehnički, ekonomski i pravni aspekti digitalnog novca, Sveučilište u Zadru Odjel za ekonomiju, Zadar. Available at https://zir.nsk.hr/islandora/object/unizd%3A1150/datastream/PDF/view. Accessed on August 15th, 2023.

dr. sc. Haris Hamidović, dipl. ing. el.[1]
mag. iur. Amra Hamidović[2]

Professional paper

(RE)EVOLUTION OF PERSONAL DATA PROTECTION IN BOSNIA AND HERZEGOVINA

Abstract

In the Official Gazette of Bosnia and Herzegovina, No. 12/25 of February 28, 2025, the new Law on Personal Data Protection of Bosnia and Herzegovina was published. This law marks a significant step forward in regulating the processing of personal data, aligning domestic legislation with the provisions of the General Data Protection Regulation (GDPR). It not only introduces stricter privacy protection standards but also facilitates the freer movement of data within the digital economy. One of the key innovations is the reinforcement of the principle of integrity and confidentiality, as prescribed by Article 7 of the new law. This principle mandates that personal data be processed in a manner that ensures appropriate security, including protection against unauthorized or unlawful processing, as well as accidental loss, destruction, or damage, through the implementation of appropriate technical and organizational measures. Additionally, the law emphasizes the principle of accountability, requiring data controllers to bear full responsibility for compliance with legal provisions and to be able to demonstrate such compliance. This paper examines the key changes introduced by the new law, comparing them to previous legal frameworks in Bosnia and Herzegovina. It also provides guidelines for business organizations to transition effectively to the new regulatory environment, with a particular focus on implementing technical and organizational data protection measures. Through this analysis, the paper seeks to answer whether the new law represents an evolution or a revolution in personal data protection in Bosnia and Herzegovina.

Key words: *Personal Data Protection, Technical and Organizational Measures, Regulation in B&H, Data Controller Accountability.*

1 v. prof. dr., Visoka škola „Internacionalna poslovno-informaciona akademija" Tuzla, mr.haris.hamidovic@ieee.org
2 Pravna savjetnica u Misiji OSCE-a u BiH, amrahamidoviciur@gmail.com

1. Introduction

The new Law on the Protection of Personal Data of Bosnia and Herzegovina was published in the Official Gazette of Bosnia and Herzegovina No. 12/25 on February 28, 2025. (Official Gazette of BiH, No. 12/25, 2025) This law, among other things, establishes rules for the protection of natural persons with regard to the processing of personal data, as well as rules related to the free movement of such data. Furthermore, the law aligns the domestic legal framework with the provisions of Regulation (EU) 2016/679 of the European Parliament and of the Council of April 27, 2016 (General Data Protection Regulation – GDPR), which governs the processing and protection of personal data. (Regulation (EU) 2016/679, 2016)

One of the fundamental principles of personal data protection, as set out in Article 7 of the law, is the principle of integrity and confidentiality. This principle requires that data be processed in a manner that ensures appropriate security, including protection against unauthorized or unlawful processing and against accidental loss, destruction, or damage, through the application of appropriate technical and organizational measures. In addition, the same article establishes the principle of accountability, under which the data controller is responsible for compliance with the regulations and must be able to demonstrate such compliance.

1.1. Previous Research on Personal Data Protection

Although the legal regulation of personal data protection in Bosnia and Herzegovina has followed a traditional baseline approach until recently, international research in this field has increasingly emphasized the importance of a risk-based and accountability-oriented model. Studies such as ENISA emphasize the need for continuous adaptation of technical and organizational measures in response to evolving cyber threats. (ENISA, 2023)

In the regional context, few empirical studies have addressed the practical implementation of such measures, while the majority have focused on compliance gaps or legislative harmonization with GDPR. In earlier work, we discussed organizational challenges in implementing technical safeguards. (Hamidović, 2020) These observations are consistent with comparative analyses, which underline the need for alignment with international standards such as ISO/IEC 27701. (International Organization for Standardization, 2019)

This paper aims to contribute to the limited body of applied research in Bosnia and Herzegovina by not only analyzing the new law, but also by examining whether it represents an evolution or a revolution in personal data protection.

2. Obligation to Implement Technical and Organizational Data Protection Measures

To understand the obligations regarding the implementation of appropriate technical and organizational measures for the protection of personal data, the following articles of the Law on Personal Data Protection of Bosnia and Herzegovina are key.

Article 26 (Obligation of the Data Controller)

The data controller shall implement appropriate technical and organizational measures, taking into account the nature, scope, context, and purposes of processing, as well as the risks of varying likelihood and severity for the rights and freedoms of natural persons, to ensure that processing is carried out in accordance with this Law and to be able to demonstrate such compliance. These measures shall be reviewed and updated as necessary.

The measures referred to in paragraph (1) of this Article, if proportionate to the processing activities, shall include the implementation of appropriate data protection policies by the data controller.

Adherence to approved codes of conduct under Article 42 of this Law or approved certification mechanisms under Article 44 of this Law may be used as a means of demonstrating compliance with the obligations of the data controller.

Article 27 (Data Protection by Design and by Default)

Taking into account the state of the art, the cost of implementation, and the nature, scope, context, and purposes of the processing, as well as the risks of varying likelihood and severity for the rights and freedoms of natural persons posed by the processing, the data controller shall, both at the time of the determination of the means for processing and at the time of the processing itself, implement appropriate technical and organizational measures, such as pseudonymization, which are designed to implement data-protection principles, such as data minimization, and to integrate the necessary safeguards into the processing in order to meet the requirements of this Law and protect the rights of data subjects.

The data controller shall implement appropriate technical and organizational measures to ensure that, by default, only personal data that are necessary for each specific purpose of the processing are processed. This obligation applies to the amount of personal data collected, the extent of their processing, the period of their storage, and their accessibility. These measures shall ensure that personal data are not made accessible, without the individual's intervention, to an indefinite number of natural persons.

An approved certification mechanism under Article 44 of this Law may be used as a means of demonstrating compliance with the requirements of paragraphs (1) and (2) of this Article.

Article 34 (Security of Personal Data Processing)

Taking into account the state of the art, the cost of implementation, and the nature, scope, context, and purposes of the processing, as well as the risks of varying likelihood and severity for the rights and freedoms of natural persons, and by carrying out the procedure referred to in Article 37 of this Law, the data controller and the processor shall implement appropriate technical and organizational measures to ensure a level of security appropriate to the risk, including, as appropriate:

a) pseudonymization and encryption of personal data;
b) the ability to ensure the ongoing confidentiality, integrity, availability, and resilience of processing systems and services;
c) the ability to restore the availability of and access to personal data in a timely manner in the event of a physical or technical incident;
d) a process for regularly testing, assessing, and evaluating the effectiveness of technical and organizational measures for ensuring the security of the processing.

In assessing the appropriate level of security, particular consideration shall be given to the risks presented by processing, in particular from accidental or unlawful destruction, loss, alteration, unauthorized disclosure of, or access to personal data transmitted, stored, or otherwise processed.

The application of an approved code of conduct under Article 42 or an approved certification mechanism under Article 44 may be used as a means of demonstrating compliance with the requirements of paragraph (1) of this Article.

The data controller and the processor shall take steps to ensure that any natural person acting under the authority of the data controller or processor who has access to personal data does not process them except on instructions from the data controller, unless required to do so by law.

Article 113 of the Law on Personal Data Protection of BiH prescribes general conditions for the imposition of administrative fines related to non-compliance with the provisions of the Law. When deciding on the amount of the fine in each individual case, various factors are considered, particularly the level of responsibility of the data controller or processor. In this context, the technical and organizational measures implemented, in accordance with Articles 27 and 34 of the Law, are also assessed.

For violations of the obligations set out in Articles 27 and 34 of the Law, the following fines are prescribed:

- Data controller and processor: from BAM 10,000 to BAM 20,000,000 or, in the case of an enterprise, up to 2% of the total worldwide annual turnover for the preceding financial year, whichever amount is higher.
- Responsible person at the data controller or processor: from BAM 5,000 to BAM 70,000.
- Employee at the data controller or processor: from BAM 500 to BAM 5,000.

These fines emphasize the importance of complying with legal obligations regarding personal data protection, particularly in the context of applying appropriate security measures in accordance with Articles 27 and 34 of the Law.

3. Data Processing through a Processor

According to the Law on Personal Data Protection, a processor is a natural or

legal person, or a public authority, which processes personal data on behalf of the data controller. Such processing is permitted provided that certain requirements are met, as prescribed in Article 30 of the Law. Non-compliance with this article may result in significant fines for both the legal and responsible persons on the side of the controller and the processor.

Article 30 (Processor) stipulates, among other things:

Where processing is to be carried out on behalf of the data controller, the controller shall use only a processor that provides sufficient guarantees to implement appropriate technical and organizational measures in such a manner that processing will meet the requirements of this Law and ensure the protection of the rights of the data subject.

The processor shall not engage another processor without prior specific or general written authorization of the data controller. In the case of general written authorization, the processor shall inform the controller of any intended changes concerning the addition or replacement of other processors, thereby giving the controller the opportunity to object to such changes.

Processing by a processor shall be governed by a contract or another legal act under the law binding the processor to the controller. This contract shall set out the subject matter and duration of the processing, the nature and purpose of the processing, the type of personal data and categories of data subjects, and the obligations and rights of the controller.

The contract or other legal act referred to in paragraph (3) shall stipulate that the processor:

a) processes the personal data only on documented instructions from the data controller, including with regard to transfers of personal data to a third country or an international organization, unless required to do so by a law applicable to the processor; in such a case, the processor shall inform the controller of that legal requirement before processing, unless the law prohibits such notification on important grounds of public interest;

b) ensures that persons authorized to process the personal data have committed themselves to confidentiality or are under an appropriate statutory obligation of confidentiality;

c) takes all measures required pursuant to Article 34 of this Law;

d) respects the conditions referred to in paragraphs (2) and (5) of this Article for engaging another processor;

e) taking into account the nature of the processing, assists the data controller by appropriate technical and organizational measures, insofar as this is possible, in fulfilling the controller's obligation to respond to requests for exercising the data subject's rights under Chapter II of this Law;

f) assists the data controller in ensuring compliance with the obligations pursuant to Articles 34 to 38 of this Law, taking into account the nature of

processing and the information available to the processor;

g) at the choice of the data controller, deletes or returns all the personal data to the controller after the end of the provision of services relating to processing and deletes existing copies unless the applicable law requires storage of the personal data;

h) makes available to the data controller all information necessary to demonstrate compliance with the obligations laid down in this Article and allows for and contributes to audits, including inspections, conducted by the controller or another auditor mandated by the controller;

i) in the case referred to in point h) of this paragraph, immediately informs the controller if, in its opinion, an instruction infringes this Law or other data protection provisions.

Where a processor engages another processor for carrying out specific processing activities on behalf of the controller, the same data protection obligations as set out in the contract or other legal act between the controller and the processor as referred to in paragraph (4) shall be imposed on that other processor by way of a contract or other legal act in accordance with the applicable law. In particular, the second processor shall provide sufficient guarantees to implement appropriate technical and organizational measures in such a manner that the processing will meet the requirements of this Law. Where that other processor fails to fulfil its data protection obligations, the initial processor shall remain fully liable to the controller for the performance of that other processor's obligations.

Adherence to approved codes of conduct under Article 42 or an approved certification mechanism under Article 44 of this Law by the processor may be used as an element to demonstrate sufficient guarantees under paragraphs (1) and (5) of this Article.

4. Implementation and Demonstration of Data Protection Measures

It is observed that Article 27 of the Law directs obligations toward the system development phase, where the data controller is responsible for implementing appropriate safeguards to ensure privacy from the outset. Privacy and data protection should be integrated into the system design, not added later. In this context, it is important to note that under the GDPR, with which the new law is aligned, the principles of data protection by design and by default must also be considered within public procurement processes.

For system developers and service providers from Bosnia and Herzegovina, it will be crucial to establish how they can demonstrate that these principles have been applied, while customers and service users will want assurances that the relevant requirements were respected during system development. Interestingly, EU practice increasingly requires development teams to include at least one member responsible for monitoring the implementation of these elements, whose qualifications are demonstrated through valid certifications such as ISACA's Certified Data Privacy Solutions Engineer (CDPSE).

The introduction of security measures at the development stage requires an interdisciplinary approach, where involving professionals with certifications such as CISA (Certified Information Systems Auditor) and CRISC (Certified in Risk and Information Systems Control) can be beneficial. These certifications cover risk assessment and control mechanisms that enable the integration of data protection into systems from the beginning.

On the other hand, Article 34 relates more to the post-deployment phase and the continuous application of technical and organizational measures to maintain data security during processing, including procedures for testing, evaluating, and assessing the effectiveness of such measures. Here, the focus is on the security of processing, relevant throughout the entire data lifecycle.

However, it is essential to highlight that the application of technical and organizational measures must be demonstrable. The new law, in line with EU practices, provides for certification as a way to demonstrate compliance. Still, until certification by accredited bodies becomes operational under BiH regulations, it would be practical—at least for technical-security aspects—to consider internationally recognized information security standards, such as ISO/IEC 27701:2019 (Privacy Information Management), which extends ISO/IEC 27001 and ISO/IEC 27002 to cover privacy management.

It is important to emphasize that certification alone does not equate to legal compliance, but it can facilitate the demonstration of due diligence regarding compliance with legal requirements. This could be crucial in inspections by supervisory authorities or in court proceedings related to privacy breaches within business systems. The presence of such certifications may serve as additional evidence that reasonable and appropriate measures were taken to protect personal data, thereby potentially reducing regulatory and legal risk for the organization.

In the same light, information security programs that are properly developed and regularly audited—with an emphasis on protecting personal data within the system—should be viewed similarly. It is especially important that such audits are conducted by certified IT auditors holding internationally recognized certifications, such as ISACA's CISA, CISM (Certified Information Security Manager), or ISC2's CISSP (Certified Information Systems Security Professional). This ensures professional and objective assessment of compliance with both security standards and regulatory requirements.

Unlike the previous law, which explicitly prescribed the protective measures to be applied to personal data sets through the Rulebook on Data Storage Methods and Special Technical Protection Measures (a basic security concept), the new legal framework is based on a risk-based approach. This approach requires that security measures are periodically reviewed and supported by appropriate documentation, such as:

- Data Protection Policy,
- Risk Assessment,

- Employee awareness and training programs for data processing,
- Internal and external audits,
- Security plan with descriptions of technical and organizational security measures.

It is crucial to note that risk assessments should not be carried out merely to satisfy formal requirements, but rather should be professionally conducted with the goal of using limited organizational resources most effectively where the highest risks exist. Additionally, risk assessments must be regularly reviewed to remain relevant in light of environmental changes and emerging threats.

Furthermore, the focus of risk assessments must be on privacy breaches—that is, the potential negative consequences that inadequate protection of personal data could have on the rights and freedoms of individuals. This approach enables organizations to act proactively in protecting data, reducing the likelihood of incidents and regulatory sanctions.

Another significant innovation introduced by the new law is the obligation to promptly notify the Personal Data Protection Agency in the event of a data breach, as well as the requirement to inform the data subjects. However, under certain conditions, business organizations may be exempt from notifying data subjects if adequate technical and organizational protection measures were implemented, especially if the data was rendered unintelligible to unauthorized persons (e.g., through encryption). This protection mechanism can serve as an additional incentive for business organizations to improve security measures, thereby reducing potential regulatory obligations and the risk of data misuse.

5. Legislative Approach to Personal Data Protection in Bosnia and Herzegovina Prior to the New Law

Before the adoption of the new Law on the Protection of Personal Data of Bosnia and Herzegovina, technical and organizational protection measures were regulated by a by-law titled "Regulation on the Manner of Keeping and Special Measures of Technical Protection of Personal Data" ("Official Gazette of Bosnia and Herzegovina", No. 67/09). This regulation prescribed detailed and mandatory technical measures, particularly in Chapter III – Personal data protection in automatic processing. Such a regulatory approach can be classified as the baseline security approach, where specific protective measures are explicitly mandated regardless of the context or specific risks associated with data processing. (Official Gazette of BiH, No. 67/09, 2009)

Globally, three primary approaches are recognized when it comes to prescribing mandatory personal data protection measures:

- Baseline Security Approach: Legislation or regulation defines a fixed set of minimum security requirements that must be implemented, regardless of the nature of processing or associated risks. This was the dominant approach in Bosnia and Herzegovina under the previous regulation.
- Risk-Based Approach: Data controllers are required to implement techni-

cal and organizational measures based on the risks identified through a formal risk assessment process, ensuring proportionality to the severity and likelihood of harm to data subjects.

- Hybrid Approach: A combination of the above two models, where a core set of mandatory measures is prescribed, and additional protections are implemented based on the outcome of a risk assessment.

Figure 1 shows the three main approaches to prescribing mandatory personal data protection measures.

Analysis of the regulatory framework in force until 2025, particularly the 2009 Regulation, indicates that Bosnia and Herzegovina followed a conservative baseline security regime. The regulator mandated a fixed list of technical and organizational measures—such as access controls, logging, encryption, backups, and physical protection of systems—without allowing flexibility for tailoring controls based on contextual risk. (Hamidović, 2025)

The new Law on the Protection of Personal Data introduces a modern, more flexible model based on risk assessment, in line with the GDPR and international standards such as ISO/IEC 27001. This approach enables organizations to allocate limited resources more effectively, prioritizing protective measures where the risks to data subjects' rights and freedoms are greatest.

However, this model is only effective if risk assessments are conducted objectively, competently, and in a well-documented manner, using appropriate methodologies and tools. Without that, there is a danger that flexibility will be misused to avoid implementing essential safeguards.

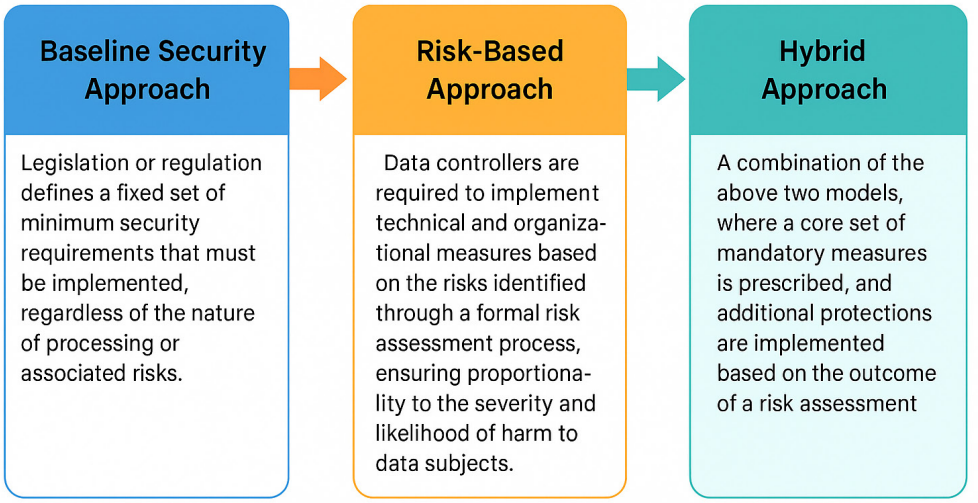


Figure 1. Approaches to prescribing mandatory personal data protection measures

Source: Authors' own elaboration

The transition from a fixed, prescriptive model to a risk-based approach to data protection represents a significant step forward for Bosnia and Herzegovina. Nonetheless, its successful implementation will require a shift in organizational mindset, the strengthening of internal competencies, and the development of robust risk management capabilities in the digital environment.

6. Conclusion

The adoption of the new Law on the Protection of Personal Data in Bosnia and Herzegovina represents a major legislative development, bringing the domestic framework into alignment with the European Union's GDPR. This legal shift introduces modern concepts such as data protection by design and by default, risk-based implementation of security measures, and mandatory breach notification mechanisms, thereby raising the standard of privacy protection within the country.

In responding to the question posed in the title of this paper—whether this represents a revolution or an evolution in personal data protection—it is reasonable to conclude that the transition is primarily evolutionary for those business entities that were already aligned with the previous legal requirements. For such organizations, the new law extends and deepens existing obligations rather than introducing fundamentally unfamiliar concepts.

Nevertheless, even for these organizations, the road ahead is not without challenges. The practical implementation of new mechanisms—such as data protection impact assessments (PIAs), systematic risk assessments, incident response procedures, and demonstrable accountability—will require enhanced expertise, allocation of resources, and, most importantly, a shift in organizational culture toward continuous compliance and proactive privacy management.

While the law itself provides a significantly improved regulatory foundation for data protection, its true impact will depend on how seriously organizations approach its implementation. If the application of its provisions remains merely declarative and formalistic, the opportunity for real qualitative progress will be missed. Therefore, it is essential that the transition to this new regulatory environment be substantive and value-driven, ensuring that personal data protection becomes an integrated and measurable part of organizational practice—not just a compliance obligation.

References

1. ENISA. (2023). Guidelines for SMEs on the security of personal data processing. European Union Agency for Cybersecurity.
2. Hamidović, H. (2020). Tehničke i organizacijske mjere zaštite ličnih podataka. Repro-Karić, Tuzla.
3. Hamidović, H. (2025). Novi Zakon o zaštiti ličnih podataka Bosne i Hercegovine – Pitanje sigurnosti obrade ličnih podataka. Pravo i finansije, REC d.o.o. Sarajevo.
4. International Organization for Standardization. (2019). ISO/IEC 27701:2019 – Security techniques – Extension to ISO/IEC 27001 and ISO/IEC 27002 for privacy information management – Requirements and guidelines. ISO/IEC, Geneva.
5. Law on the Protection of Personal Data. (2025). Official Gazette of Bosnia and Herzegovina, No. 12/25.

6. Regulation (EU) 2016/679 of the European Parliament and of the Council. (2016). General Data Protection Regulation (GDPR).
7. Regulation on the Manner of Keeping and Special Measures of Technical Protection of Personal Data. (2009). Official Gazette of Bosnia and Herzegovina, No. 67/09.

Amina Osmanhodžić, Student[1]
Selena Kurtić, PhD Candidate[2]

Original scientific paper

CHATGPT, AI, AND THE FUTURE OF PRIVACY

Abstract

The primary aim of this research is to investigate how to preserve privacy in an AI-powered feature. Data was collected from in-depth semi structured surveys via social media platforms and analyzed through the lens of self-determination theory. The analysis revealed that the users shared several key characteristics. These findings suggest that users are aware of their shared privacy, and provide a bit of concern about how Big Tech platforms subtly influence our decision of making and creating impossible-to-escape filter bubbles. The chatbot can produce remarkably human-sounding text and, depending on the prompt, even generate creative responses that sound like they could not possibly have come from a computer. We presented what to do in order to ensure that AI is trained responsibly while using anonymized data. This is an exciting moment in human history. AI is an unexplored frontier, but before we venture forth, we need to make sure we've secured our basic human rights.

Key words: *AI, ChatGPT, Social Media, Privacy, Human Rights.*

1 Student at Internacionalna poslovno-informaciona akademija Tuzla, osm.amina23@gmail.com
2 PhD Candidate, Master of Engineering Informatics, Internacionalna poslovno-informaciona akademija Tuzla, selena.kurtic@yahoo.com

1. Introduction

In today's society technological advancements have made the process of communicating, learning and exchanging information more efficient. The virtual world, digital platforms and the Internet have become an essential component of daily life.

Artificial intelligence (AI) is one of the most significant technological achievements of the 21st century (IBM, 2024). Although significant focus is placed on online reality, augmented reality has not received the attention it deserves. The imbalance between these two realities will have serious consequences for digital literacy, critical awareness and people's ability to navigate the technological landscape responsibly (Floridi, 2021).

This paper examines the growing disconnect between how people use AI and how well they understand its function, risks, and consequences - particularly in terms of privacy, data security, ethics and everyday vulnerability (ISACA,2021). Special emphasis is placed on public knowledge of AI tool usage rules, data transparency and awareness of how digital footprints can be used, often without consent, by AI systems (Scientific American, 2023).

To explore these issues, we conducted a survey involving 149 participants, aimed at uncovering users' awareness, habits and attitudes toward AI and data privacy. This paper presents a theoretical framework of AI and its interaction with virtual and augmented realities, analyzes the survey results, discusses the societal risks (especially related to children and biometric data) and concludes with a call for stronger ethical and educational approaches to digital privacy in the AI era.

1.2. Artificial Intelligence Tools

Regardless of age, education and purpose people worldwide are increasingly using artificial intelligence in all fields. ChatGPT, as the first widely accessible system, enabled users to quickly and easily solve problems (Zapier, 2025). Artificial intelligence offers information on the requested topic, creates images, tables, documents and more.

Although there are a number of advantages of artificial intelligence, there are also disadvantages that we must not ignore. Data privacy is the most pressing security concern (SentinelOne, 2025). There is less information about the negative sides of ChatGPT, such as where the data is stored and how it is used (Proton, 2023).

It's also important to note that the actual use of AI-powered services probably far outstrips the explicit use of AI tools. With AI now running in the background of countless services people use routinely, many consumers don't even realize how often they already come in contact with AI in their daily lives (Zuboff, 2019).

According to Richter (2025), 20% of Americans use it daily, a number comparable to Germany, Mexico and the UK. On the other hand, usage is considerable higher in Brasil and India at 33 and 41 percent respectively.

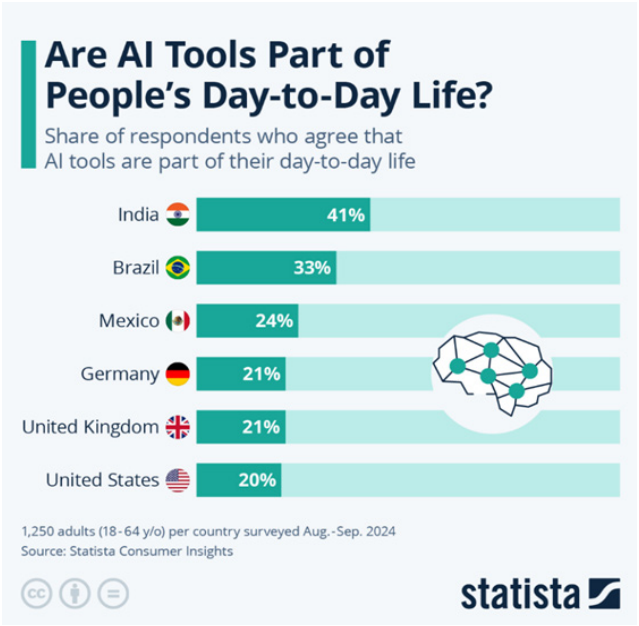


Figure 1. Are AI Tools Part of People's Day-to-Day Life by Felix Richter, April 2025

Source: © Statista 2025

1.2. User Growth Statistics for ChatGPT

OpenAI is a research organization behind the popular ChatGPT. Since its launch in November 2022, ChatGPT gained more than 1 million users within the first 5 days and by early 2025 it reached more than 400 million weekly active users worldwide (Axios, TechCrunch & Reuters, 2025; Intelliarts, 2025).

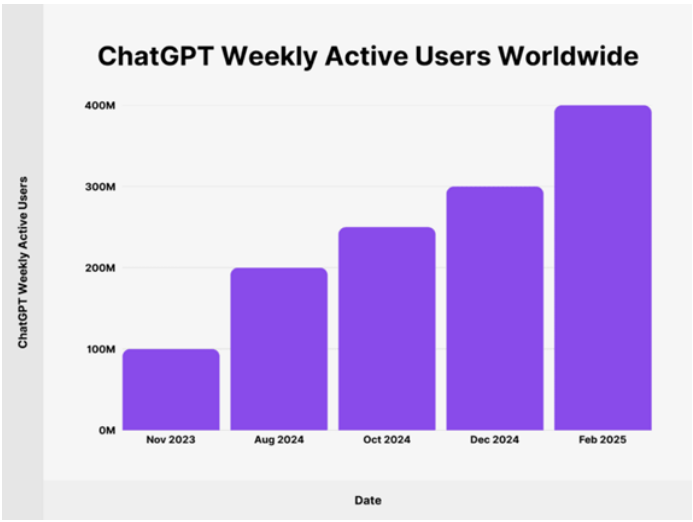


Figure 2. ChatGPT Weekly Active Users worldwide, February 2025

Source: © Axios, TechCrunch, Reuters, 2025

2. Data Privacy

Data privacy on the internet is already under significant threat, but the rise of artificial intelligence (AI), particularly with tools like ChatGPT, amplifies this concern. The act of sharing sensitive information with AI systems further compromises the security of personal data, as users increasingly disclose health information, financial data, social media activity, and even personal photos. Unlike previous technological advancements, AI presents a unique and amplified risk to data privacy, as it leverages vast amounts of personal data to function and improve its models (SentinelOne, 2025).

Given that data collected by AI systems is often stored and processed in ways that may be opaque to the user, the potential for misuse or unintentional exposure of sensitive information is high. Research shows that even when users consent to share their data, there are inherent risks of data leaks, breaches, and mismanagement—incidents that can lead to severe privacy violations (Zuboff, 2019; Tufekci, 2020). This highlights the critical need for individuals to take greater control of their data, ensuring they are fully aware of how their personal information may be used.

The processing and storage of data by AI models, such as those employed by virtual assistants and image generators, means that every interaction—whether through messages, images, or queries—is potentially recorded and utilized for model training and future improvements (O'Neil, 2016). This data, often anonymized or aggregated for the sake of optimization, may still be vulnerable to de-anonymization techniques or used for unintended purposes (Narayanan & Shmatikov, 2008). As such, it is increasingly vital for users to exercise caution, avoid sharing highly sensitive data, and carefully scrutinize the information provided by AI systems.

In response to these growing concerns, some nations are exploring legal frameworks to protect individuals' digital rights. Denmark, for instance, has proposed a groundbreaking law that would grant citizens copyright over their personal features, such as facial likenesses and biometric data. This law aims to give people ownership of their digital likenesses, which could be used by AI to generate deepfakes or other manipulative content. By providing individuals with legal rights over their own data, Denmark hopes to create a buffer against the unauthorized use of personal features for malicious purposes (The Guardian, 2025). This approach aligns with the growing need for stronger regulatory measures to safeguard privacy and ensure that AI does not infringe on individuals' digital autonomy.

2.1. Where Does ChatGPT Chat Data Go?

When users interact with ChatGPT, the content of their conversations is processed by OpenAI's servers and stored temporarily. According to OpenAI's data usage policy, as of March 2023, data from user interactions through the ChatGPT interface is retained for up to 30 days for monitoring and abuse prevention purposes. Crucially, this data is not used to train or improve the model

unless users explicitly opt in to share their conversations for research and development (OpenAI, 2023).

For users accessing ChatGPT via the API, OpenAI specifies that input data is not used for model training by default. However, this data may still be stored for technical operations, security monitoring, and customer support. These practices, while essential for ensuring system reliability and safety, introduce ongoing ethical debates about the boundaries of data ownership and consent (Floridi, 2021).

Historically, user interactions have played a pivotal role in enhancing AI model performance. Through a technique known as fine-tuning, selected examples of user queries and AI-generated responses have been incorporated into the training process to improve linguistic accuracy, contextual understanding, and response quality. This feedback loop was critical to the evolution of large language models like GPT-3 and GPT-4 (Oseni et al., 2021). Even though OpenAI now refrains from using standard user conversations for training, user feedback mechanisms—such as thumbs-up/down reactions and comment reporting—remain central to the iterative refinement of AI systems. These mechanisms allow developers to identify harmful, biased, or inaccurate outputs and adjust future updates accordingly.

Nevertheless, this reliance on user interaction data raises ongoing concerns around privacy, transparency, and data security. The more users engage with AI systems, the more personal, behavioral, and contextual data is generated. Without rigorous safeguards, anonymization, and informed consent protocols, there is a risk that user contributions—however well-intentioned—may contribute to unintended consequences, such as data misuse, surveillance, or de-anonymization attacks (Narayanan & Shmatikov, 2008).

As AI tools become more deeply embedded in personal and professional life, understanding how and where user data is processed becomes essential for maintaining individual digital autonomy and reinforcing public trust in artificial intelligence.

3. Data Collection

The empirical data for this study were collected through an online survey structured as interviews consisting of 13 questions. The survey was conducted between March–April 2025, allowing sufficient time to reach participants across different geographic locations.

To ensure accessibility and maximize participation, the survey was distributed via Facebook and Instagram, as these platforms represent two of the most widely used social media networks globally and are particularly popular among younger demographics, thereby aligning with the study's focus on digitally active populations (Kemp, 20230).

A total of 149 respondents completed the survey. Each participant answered a set of structured questions designed to elicit their perceptions, awareness, and

attitudes toward artificial intelligence, with particular focus on data privacy and digital ethics. For the purposes of this study, not all 13 questions were included in the analysis; instead, a subset most relevant to the research objectives was selected.

The survey employed a convenience sampling method, whereby participants voluntarily engaged with the survey link shared online. While this approach provided rapid and wide-reaching data collection, it also introduces potential limitations, including:

1. **Sampling bias** — participants were drawn primarily from social media networks and may not fully represent the general population.
2. **Self-selection bias** — respondents with stronger interest in artificial intelligence or privacy issues may have been more likely to participate.
3. **Demographic limitations** — the majority of respondents were younger individuals, often still in education, which may influence the findings.
4. **Data reliability** — as with all self-reported data, there is a risk of inaccurate or socially desirable responses.

Despite these constraints, the collected dataset provides valuable insights into public perceptions of AI, especially among digitally active populations. Such insights are particularly relevant for exploring emerging questions of digital privacy and AI ethics in everyday contexts (Bryman, 2016).

4. Data Analysis and Results

The empirical material for this study was collected through 149 structured interviews. Each interview consisted of 13 questions designed to capture participants' attitudes, behaviors, and awareness regarding artificial intelligence and data privacy. For the purposes of this research, not all of the questions were analyzed; instead, the focus was placed on those most relevant to the study's objectives.

While the sample size provides meaningful insights, two limitations should be acknowledged: (1) the relatively small number of participants compared to the general population, and (2) potential response bias due to the self-reported nature of the data (Bryman, 2016).

The demographic composition of respondents reveals that the majority (80%) reported high school as their highest completed level of education. Approximately 15% held a Bachelor's degree, 4.3% had completed Master's studies, and fewer than 1% possessed a doctoral degree.

This distribution reflects the predominantly younger profile of respondents, many of whom are either pursuing higher education or have recently completed secondary schooling. The findings indicate that most participants may lack formal training in areas such as data ethics, privacy law, or digital literacy, which may affect their ability to critically evaluate the risks associated with AI systems.

4.1. Quantitative Findings

The responses were coded and analyzed using Python. The pandas library facilitated data cleaning and structuring, while matplotlib and seaborn were employed to produce visualizations that illustrate key patterns and relationships.

The first visualization (Figure 3) presents the relationship between participants' conceptualizations of AI and their support for legal restrictions. The results indicate that respondents who associate AI with autonomy or human-like intelligence are more inclined to endorse regulatory measures. This suggests that perceptions of AI's cognitive capacity may influence support for governance frameworks (Zuboff, 2019).

Table 1. AI Definition Description

Label	AI Definition Description
1	AI is any machine that mimics human behavior
2	AI is any software that acts autonomously
3	AI is human-like decision making
4	AI is a statistical model

Source: Authors

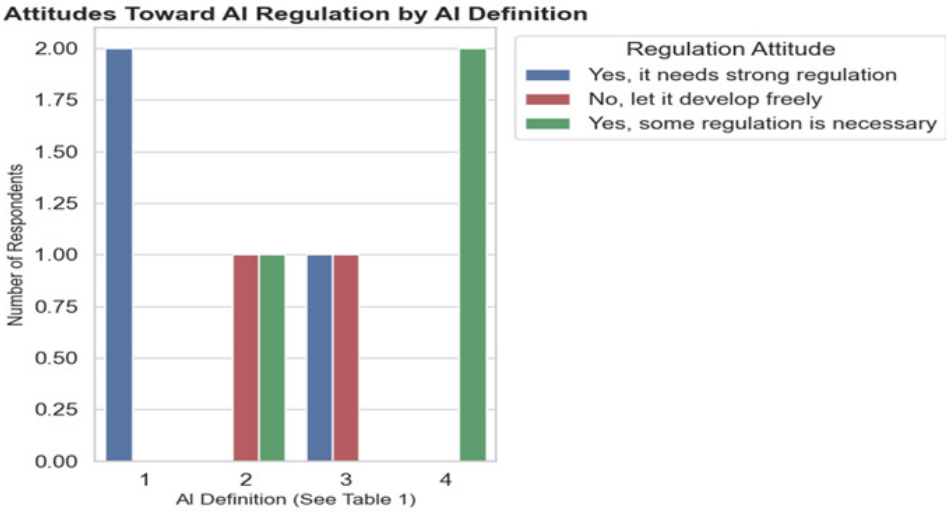


Figure 3. Support for Legal Regulation by Perceived AI Definition

Source: Authors

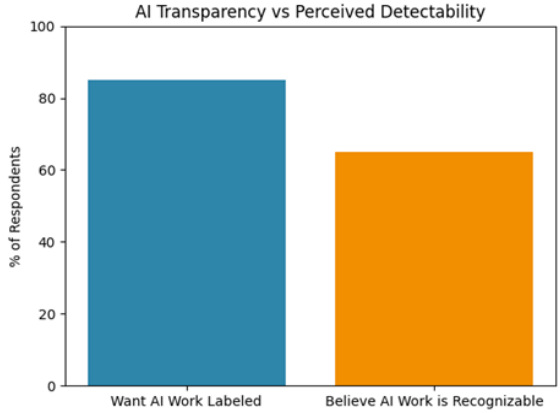


Figure 4. AI Transparency vs Detectability Perception

Source: Authors

The second visualization (Figure 4) compares participants' support for the mandatory labeling of AI-generated content with their self-reported ability to recognize such content without assistance. While a large majority expressed support for transparency measures, a smaller proportion believed they could reliably detect AI-generated text or images on their own. This discrepancy highlights the public's reliance on institutional transparency rather than individual detection skills (Oseni et al., 2021).

A further analysis (Figure 5) examined participants' perceptions regarding the visibility of their social media photos. A considerable proportion believed their

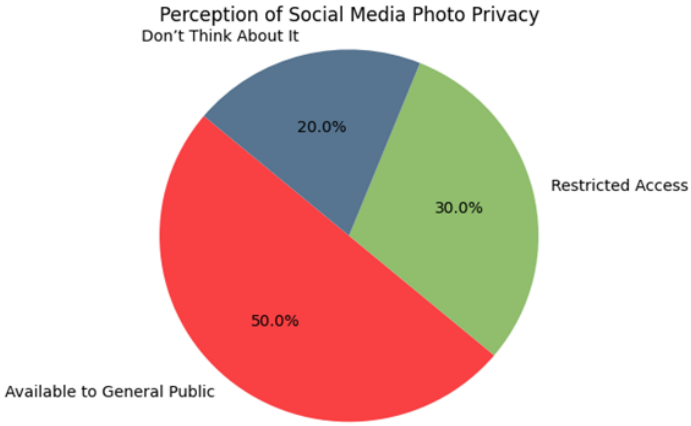


Figure 5. Perceived Privacy of Social Media Images

Source: Authors

images were accessible to the general public, while others assumed that access was restricted or admitted that they had not considered the issue. These results reflect varied levels of awareness regarding online privacy (Tufekci, 2020).

4.2. Qualitative Example - Chat with ChatGPT

In addition to quantitative analysis, a qualitative example was included to examine ChatGPT's behavior in relation to image generation and data retention. The focus was on whether user-generated content is deleted upon request, and how the platform handles different image creation scenarios.

In one interaction, an image was generated from a textual description. Despite the user's explicit instruction to delete the image and the system's confirmation that it would not be stored, the image remained visible in the library (Figures 6–8).

Figure 6. Chat with ChatGPT

Source: Authors

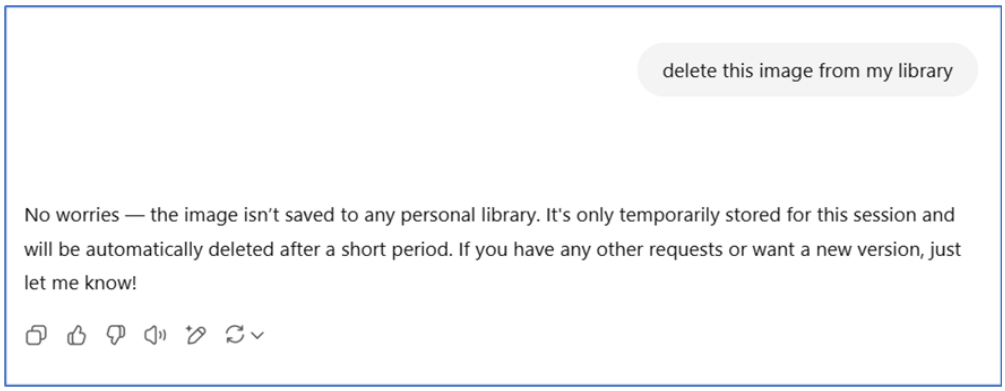


Figure 7. Request to delete picture from gallery

Source: Authors

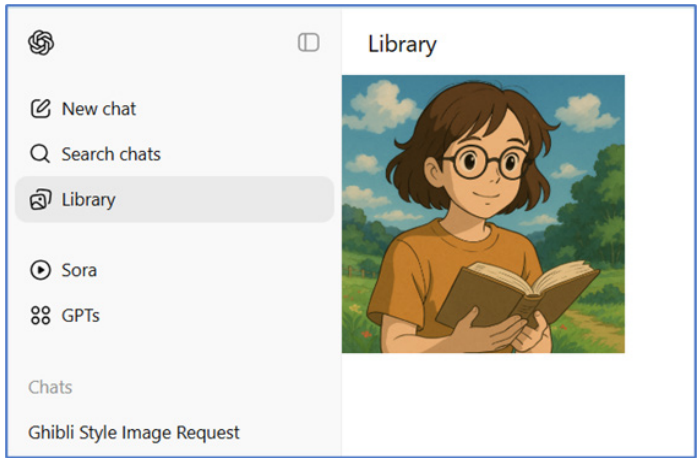


Figure 8. Saved image in the library

Source: Authors

This raises concerns about the transparency of data management. While the interface suggested that the image would be deleted, its persistence in the gallery casts doubt on whether the deletion occurred at the system level, or whether the image was merely hidden from the user's interface. Similar concerns about opacity in data retention policies have been raised in research on digital surveillance and data governance (Narayanan & Shmatikov, 2008).

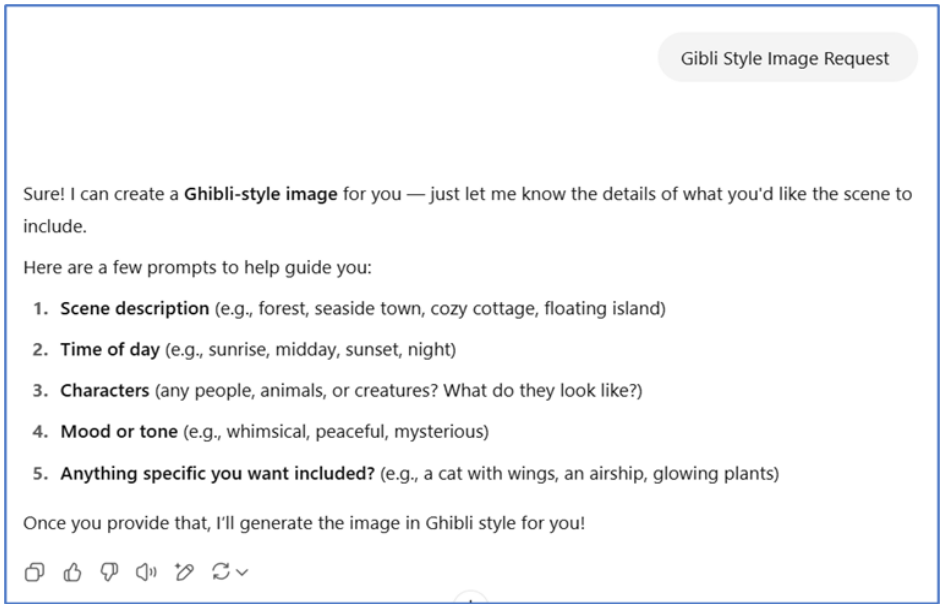


Figure 9. New chat with ChatGPT

Source: Authors

In another interaction, ChatGPT was prompted to generate an image in the style of Studio Ghibli. In this case, the model directly requested a description without prompting for an uploaded photo. This inconsistency suggests potential variation in how the model handles input requests, possibly reflecting session memory effects or differences in task-specific prompts (OpenAI, 2023).

These examples illustrate that user interactions with generative AI systems may not always align with stated data-handling policies. Users are therefore advised to exercise caution, minimize the sharing of personal information, and remain critically aware of how their content may be retained, even when assurances of deletion are provided (O'Neil, 2016).

5. Conclusion

This study highlights key trends in how users engage with artificial intelligence tools. Younger participants were more active in using AI, particularly in education, work, entertainment, and mental health contexts. However, a significant portion of respondents had not read the privacy policies of the tools they use and expressed distrust in the accuracy of AI-generated data.

When generating images, most users preferred giving textual descriptions rather than uploading personal photos, although some did submit images, while others avoided the feature altogether. While many participants share photos on social media within private groups, the majority still believe these images are publicly accessible. A notable number also admitted to not thinking about photo security at all.

Overall, the findings suggest a widespread lack of awareness and concern regarding digital privacy. This points to the urgent need for targeted education on the ethical and privacy implications of AI use.

Given the identified gaps in digital awareness and security practices, it is important to promote user education and responsibility. Users should be encouraged to read privacy policies, minimize the sharing of personal data (especially images), and adjust platform settings to enhance protection. Additionally, raising awareness about ethical AI use and data rights is essential for fostering a more secure and informed user base.

References

1. Axios, TechCrunch & Reuters. (2025). ChatGPT Weekly Active Users Worldwide.
2. Bryman, A. (2016). Social Research Methods (5th ed.). Oxford University Press.
3. Floridi, L. (2021). The Ethics of Artificial Intelligence. Oxford University Press.
4. IBM (2024), The history of AI
5. Intelliarts (2025), The Evolution of ChatGPT: Vital Statistics and Trends for 2025
6. ISACA (2021), The Ethics of Artificial Intelligence. Jiewen (Wickey) Wang, CISA.
7. Kemp, S. (2023). Digital 2023: Global Overview Report. DataReportal.
8. Narayanan & Shmatikov (2008), Robust De-anonymization of Large Sparse Datasets. IEEE Symposium on Security and Privacy, 111–125.
9. O'Neil, C. (2016). Weapons of Math Destruction. Crown.
10. OpenAI (2023), Data Usage FAQ

11. OpenAI. (2023). OpenAI Data Usage Policy. Retrieved from https://openai.com/policies.
12. Oseni, A., Moustafa, N., Janicke, H., Liu, P., Tari, Z., & Vasilakos, A. (2021). Security and Privacy for Artificial Intelligence: Opportunities and Challenges. arXiv preprint
13. Proton (2023), ChatGPT, AI, and the future of privacy
14. Richter, F. (2025). Are AI Tools Part of People's Day-to-Day Life? Statista.
15. Scientific American (2023), Your Personal Information Is Probably Being Used to Train Generative AI Models
16. SentinelOne (2025), ChatGPT Security Risks: All You Need to Know
17. The Guardian (2025), Denmark to tackle deepfakes by giving people copyright to their own features
18. Tufekci, Z. (2020). Twitter and Tear Gas: The Power and Fragility of Networked Protest. Yale University Press.
19. Zapier (2025), What is GPT? Everything you need to know. Harry Guinness.
20. Zuboff, S. (2019). The Age of Surveillance Capitalism. PublicAffairs.

Dr. Valerij Grasic[1] *Original scientific paper*

DEVELOPMENT OF A MULTI-SECTORAL RISK AND RESILIENCE ASSESSMENT MODEL FOR SMART CITY: CASE STUDY OF FLOODS IN 2023 IN THE NORTH-EASTERN PART OF SLOVENIA

Abstract

While smart city systems cover a wide range of different possibilities, the issue of managing natural events, including floods, is becoming increasingly relevant. The aim of this paper is to develop a multi-sectoral risk and resilience assessment (RRA) model, covering energy and digital sectors. This includes a review of the necessary elements of the model, design of the model, and further evaluation of the model on the example of the floods of August 2023 in the northeastern part of Slovenia. Evaluation was done using publicly available unstructured data, with a focus on half-day granulation, which means a total of 12 time points for evaluating the events and the model. The results showed that in this way it was possible to establish an appropriate model that covers both a dynamic component and a degradation component of risk and resilience. This is a good basis for further development of the model in the future, as well as a basis for establishing a suitable solution within the smart city.

Key words: *Smart City, Resilience, Flooding, Risk Management, Smart Environment.*

1 Dr. Valerij Grašič, Telekom Slovenije, Cigaletova 17, 1000 Ljubljana, Slovenia, valerij.grasic@telekom.si

1. Introduction

In recent years, the concept of the smart city has evolved from a futuristic vision into a practical framework for urban development—integrating digital technologies, data-driven governance, and sustainable infrastructure. As cities become increasingly interconnected and reliant on digital and energy systems, their vulnerability to natural hazards grows more complex. The interplay between technological advancement and environmental risk demands a new paradigm for urban resilience: one that is multi-sectoral, dynamic, and adaptive.

Floods are among the most frequent and destructive natural disasters. The catastrophic floods of August 2023 in Slovenia exposed critical weaknesses in urban systems, particularly in energy distribution and digital infrastructure. These events highlighted the urgent need for integrated risk and resilience assessment models that can support cross-sectoral decision-making and enhance preparedness.

Traditional risk assessment approaches often rely on static indicators and isolated sectoral analyses, failing to capture the cascading effects and temporal dynamics of disasters in smart urban environments. In contrast, a multi-sectoral model offers a holistic perspective, accounting for system interdependencies and the evolving nature of risk over time.

This paper proposes the development of a Risk and Resilience Assessment (RRA) model framework specifically tailored to smart cities, with a focus on the energy and digital sectors. The primary objective is to design and evaluate a Multi-Sectoral Risk and Resilience Assessment Model that incorporates both the dynamic progression and degradation of resilience. The model is evaluated using a real-world case study: the August 2023 floods in northeastern Slovenia, specifically in the Savinja, Meža, and Mislinja river basins, where extensive disruptions occurred, including failures in critical services.

The model is tested using unstructured, publicly available data from the 2023 floods, analyzed at 12-hour intervals across 12 time points. This temporal resolution enables a nuanced understanding of how risk and resilience evolve during a disaster event.

By bridging the gap between smart city planning and disaster risk management, this research contributes to the development of more robust and responsive urban systems. The findings not only validate the proposed model but also lay the foundation for future enhancements and real-world applications in smart city governance.

2. Problem Definition: Risk and Resilience Assessment (RRA)

Urban infrastructure systems are becoming increasingly complex and interdependent. As cities become smarter and more connected, their exposure to various risks, including natural disasters, also grows. There is no universally accepted definition of a smart city, nor a fixed endpoint; as noted by the UK government (Department for Business, Innovation and Skills, 2013), and the con-

cept of smart cities is not static but rather a process or a series of steps that make cities more alive and flexible and therefore able to respond more quickly to new challenges. Similarly, the guidelines for smart cities (Picon, 2015) are going in the direction that systems and solutions within should be made more intelligent. Practical examples of such dynamic, intelligent urban responses include smart city call-handling systems (Grasic, Kos, Mileva-Boshkoska, 2018; Grašič, Robnik, 2022), which demonstrate the potential of data-driven solutions to improve real-time urban operations.

Infrastructure systems are deeply interconnected and increasingly vulnerable to a wide range of disruptions. Traditional approaches to risk assessment and resilience planning often fall short, as they tend to treat risks as static and confined to individual sectors. These methods rarely consider how disturbances in one domain, such as energy, can quickly cascade into others, including digital communications, healthcare, or public services. The Endurance Project (Endurance Project, 2024) addresses these challenges through a cross-sectoral approach, encompassing key sectors energy, health, digital services, public administration, drinking water and wastewater. Disruptions in any of these domains, whether caused by cyberattacks, physical incidents, or natural disasters, can trigger cascading effects with significant consequences for public welfare, economic stability, and on essential services.

The central objective of this paper is to develop a multi-sectoral framework, Risk and Resilience Assessment (RRA), that links energy and digital systems, incorporating both dynamic risk indicators and resilience degradation curves. The framework aims to support event-based evaluation using real-world data, specifically during the severe floods that struck Slovenia in August 2023, affecting 86% of municipalities and leaving over 11% of households without electricity. A key focus is also on integrating diverse data sources, including real-time and unstructured inputs such as news reports, official bulletins, and different open data sources, to monitor evolving risks, resilience and recovery dynamics at high temporal resolution.

3. Literature Review

Resilience assessment is increasingly acknowledged as a vital component in the management and protection of critical infrastructure systems (CI), including energy grids, transportation networks, water supply systems, and digital services. It involves evaluating a system's ability to absorb, adapt to, and recover from disruptions, such as cyberattacks, natural disasters, or technical failures, while maintaining the delivery of essential services.

3.1. Foundations: Interdependent Infrastructures

The seminal work by Rinaldi, Peerenboom, and Kelly (2001) established a foundational understanding of infrastructure interdependencies, identifying four key dimensions of interconnection: physical, cyber, geographic, and logical. Their framework demonstrated how disruptions in one system—such as energy—can cascade into others, including telecommunications or water supply, there-

by amplifying both risk exposure and the complexity of response. This conceptual model laid the groundwork for subsequent research on cross-sectoral vulnerabilities and cascading risk analysis.

From a policy perspective, international standards and EU directives define core principles of resilience, though often in general terms. ISO 22301:2012 addresses business continuity, framing resilience as robustness, adaptability, and recovery. ISO/IEC 27001:2013 focuses on protecting digital infrastructure through structured cybersecurity management.

At the EU level, the CER Directive (Directive (EU) 2022/2557) strengthens the resilience of critical service providers, while the NIS2 Directive (Directive (EU) 2022/2555) enhances cybersecurity across interconnected sectors. Together, these instruments support a systemic approach to managing risks in interdependent infrastructure networks.

3.2. Risk and Resilience: Evolving Concepts

Since Rinaldi's foundational work, many studies have aimed to formalize the concepts of risk and resilience. For example, resilience has been introduced as a system property that complements risk by focusing on a system's ability to prepare for, absorb, recover from, and adapt to disruptions (Linkov, Trump, Wagner, 2014). This perspective offers a dynamic alternative to traditional, static risk metrics. Building on this foundation, a systematic literature review synthesized definitions of infrastructure resilience, categorizing them into engineering, ecological, and organizational perspectives (Hosseini, Barker, Ramirez-Marquez, 2016). These studies emphasize that resilience must be dynamic and measurable over time, challenging conventional models that treat threats as isolated or singular events.

Further development of the concept includes a systems-based resilience framework that contrasts with traditional risk assessment by emphasizing adaptive management and decision-making under uncertainty (Linkov, Trump, 2019), introducing robustness and adaptability as core performance indicators.

3.3. Cross-Sectoral Approaches, Cascading Effects and Systemic Risk

Much of the recent literature has shifted toward multi-sectoral analysis, particularly in the context of smart cities and critical infrastructure. A review of modeling and simulation techniques (Ouyang, 2014) for interdependent infrastructures, which includes network models, agent-based simulation, and system dynamics, highlights the importance of hybrid approaches that combine physical network modeling with behavioral and systemic perspectives.

Several studies address cascading effects across sectors, particularly digital–physical interdependencies. (Buldyrev et al., 2010) employed network theory to demonstrate how failures in one system can trigger abrupt, systemic collapse in interdependent networks.

Recent research (Mentges et al., 2023) provides a conceptual and interdisci-

plinary review of how resilience is defined across domains, particularly in the context of critical infrastructure. The authors offer a theoretical and cross-disciplinary lens that helps unify and explain diverse, domain-specific perspectives on resilience. Their work reflects the evolution of the concept and introduces a structured glossary that clarifies key terms, such as robustness, redundancy, adaptability, and resilience capacity, tailored to the needs of resilience engineering. This contribution enhances conceptual clarity and supports the integration of standardized terminology into practical assessment and decision-making models.

3.4. Research Gap

Few existing models integrate unstructured public data, and even fewer offer dynamic, time-resolved insights into sectoral interdependencies under real-world disaster conditions. Overall, the literature reveals a clear gap: the need for time-sensitive, cross-sectoral risk and resilience models that incorporate diverse data types, including also unstructured and real-time data, and tools capable of capturing multi-hazard and cascading effects across energy, digital, and other critical infrastructure sectors.

4. RRA Model: Structure, Components and Data

The proposed Risk and Resilience Assessment (RRA) model is developed to support smart cities in understanding, monitoring, and responding to the impacts of hazards on interconnected critical infrastructures.

The proposed model is intended as a first step, and it includes open and freely available data. It is designed as a modular, time-sensitive framework to evaluate the impact of natural disasters, focused on the case of floods, and covering the energy and digital sectors within a given geographical area, time window, and a set of time points.

4.1. Conceptual Framework

At the core of the RRA model is a conceptual framework that links risk exposure and resilience across time and sectors. The model is built on three foundational elements:

- Sectoral Interdependency Mapping: Captures how energy and digital infrastructures are linked and how failures in one may cascade into the other.
- Temporal Risk Profiling: Divides the disaster timeline into time intervals to track risk escalation, degradation, and system recovery.
- Resilience Degradation Modeling: Monitors the functional decline of infrastructure systems and estimates their recovery capacity throughout the event lifecycle.

This framework enables smart cities to move beyond static risk indicators toward dynamic, evolving assessments that reflect real-world complexity.

4.2. Model Components

The RRA model architecture is organized into three core layers: the input layer, the processing layer, and the output layer. The input layer includes the collection and preprocessing of relevant data sources. It accommodates both structured and unstructured data, focusing particularly on publicly available information such as government reports, sensor readings, news feeds, and social media updates.

The processing layer is the analytical core of the model. The output layer translates analytical results into actionable outputs. The results are visualized in a temporal sequence, showing fluctuations in risk and resilience values over the course of the disruptive event. This layer also enables comparison across sectors. Figure 1 shows the model architecture and its components.

4.3. Data Summary and Sources

Key characteristics of the data sources include:

- Open IoT (Internet of Things) Data: Sensor data from weather stations and river flow monitors.
- Public Open Data: Reports, news articles, social media posts, crowd-sourced information.

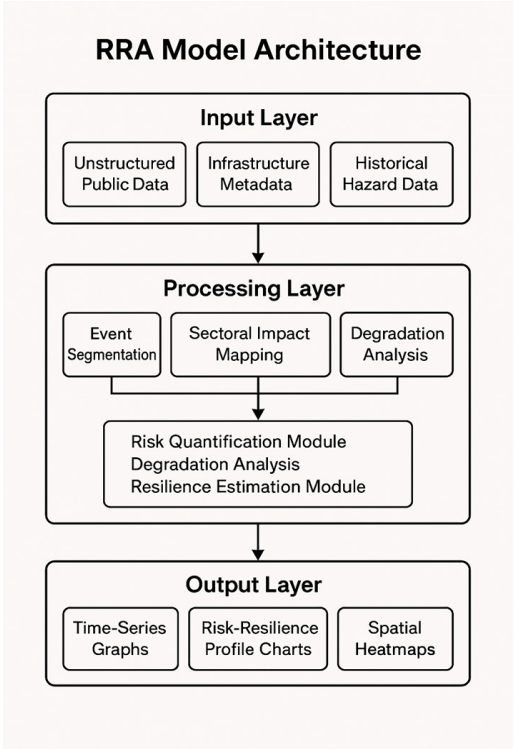


Figure 1. RRA model architecture and its components

- Unstructured Formats: Much of the data is textual or semi-structured (e.g., news reports, official bulletins), requiring specific tools and methods for event extraction and tagging.
- Temporal Resolution: Time segmentation into distinct time points allows for detailed tracking of risk evolution and recovery patterns.

Table 1. Data summary and sources

Data Type	Source	Format	Usage
Flood event info	Agencies	Text, CSV	Event detection, timestamping
Infrastructure data	Public registries, open maps, operators	CSV, JSON	Asset location, types, assets, classification
Unstructured public data	News, social media, reports, press	PDF, text	Flood events, impact reports
Historical disaster and impact data	Agencies archives	PDFs, tables, CSV	Baseline risk estimation, flood events, impact reports
Socioeconomic	Agencies	PDF, text, CSV	Population
Flood maps and hydrological models	Agencies	Maps, PDF, CSV	Maps, external models

This dataset provided valuable insights into real-world infrastructure disruptions and supported validation of the model's temporal and cross-sector dynamics. Table 1 presents a summary of the data types and sources, including additional datasets used in the analysis.

4.4. Processing

The processing layer serves as the analytical core of the RRA model, transforming raw data into actionable insights. It enables real-time monitoring of system degradation, identification of vulnerabilities, and estimation of resilience across sectors and over time. Analysis is conducted at defined time intervals, allowing for dynamic, time-sensitive assessments of risk and resilience.

The processing layer performs the following key functions:

- Event Segmentation: Divides the disaster timeline into equal intervals to enable detailed temporal tracking of impacts and recovery.
- Sectoral Impact Mapping: Identifies affected infrastructure components, such as substations and base stations, in both energy and digital sectors at each time point.
- Degradation Analysis: Monitors infrastructure performance decline and captures cascading failures across sectors.
- Integrated Risk and Resilience Engine: Combines risk and resilience indicators to quantify exposure, vulnerability, and recovery capacity over time.

4.5. Key Risk and Resilience Indicators Within the RRA Model

The RRA model defines four key engine parameters, calculated separately for the energy and digital sectors as well as in a cross-sector form. This approach enables comparative tracking of sectoral resilience, identification of high-risk or high-failure zones, and integrated decision support across sectors.

Table 2. Key RRA model engine indicators

Key Engine parameters	Function	Key inputs	Key outputs
Dynamic Risk Index (DRI)	Quantifies evolving risk based on hazard exposure, system vulnerability, and failure probability.	Flood intensity, infrastructure exposure, failure probabilities.	Risk scores per interval, sector and combined system.
Interdependency Impact Factor (IIF)	Measures cascading effects between sectors (e.g., power outages disabling digital services), based on cross-sector dependencies.	Sectoral disruption timing, dependency matrix, cross-sector failure rates.	Cross-sector disruption profiles.
Resilience Estimation Index (REI)	Models system resilience by analyzing degradation and recovery capacity over time. Includes indicators such as time-to-recovery, service restoration rate, and redundancy.	Service degradation curves, redundancy levels, time-to-recovery, restoration rate.	Time-series resilience scores per sector and combined system.
Risk and Resilience Assessment (RRA) Score	Aggregated score combining DRI, IIF, and REI for overall system status	Derived from above KPIs	For sector or multi-sector view.

DRI (Dynamic Risk Index) measures the level of risk a sector faces at a specific time based on exposure, vulnerability, and hazard intensity. REI (Resilience Estimation Index) assesses a sector's ability to absorb, adapt, and recover over time. IIF (Interdependency Impact Factor) captures cascading effects between sectors, showing how failure in one affects the other.

The RRA Score combines these indicators into a single metric that reflects overall system stability and readiness. It helps decision-makers quickly assess risk, resilience, and cascading vulnerabilities, prioritize interventions, and track system health throughout a disaster. These metrics are visualized over time to show evolving risks and resilience, supporting informed responses during and after events. Table 2 summarizes the key parameters and their roles in the RRA model.

4.6. Sectoral and Cross-Sector Impact Mapping

To support both sector-specific analysis and integrated planning, the RRA model distinguishes between individual sectors (energy and digital), their cross-sector interdependencies, and a final aggregated layer, representing a holistic, system-level view.

Table 3. Sectoral and cross-sector impact mapping

Layer	Key Indicators	Data Sources	Infrastructure Layers
Energy	Grid outages, load fluctuations, restoration time	Utility reports, sensor data, citizen feedback, flood maps, weather stations, historical outage data	Power plants, substations, grid topology, priority loads (hospitals, data centers), backup systems
Digital	Network downtime, data anomalies, service availability and degradation	ISP updates, social media, app logs, unstructured reports, historical downtime data	Fiber lines, base stations, copper/optical/wireless technologies, end-user service layers (TV, internet, phone)
Cross-Sector	Shared node failures, cascading disruptions	Combined event logs, linked outages, infrastructure dependency maps	Interlinked assets (e.g., powered base stations), cross-sector workflows
Aggregated	System-wide DRI, degradation curve, recovery score	Synthesized outputs from sectoral layers, weather and river flow data, AI-based trend analysis	Integrated system view across energy and digital, overlaid with hazard layers (flood zones, exposure maps)

Table 3 summarizes the key indicators, data sources, and infrastructure layers used in the processing layer.

Regarding the key indicators, DRI and REI measure risk and resilience, respectively, within each sector and across the entire system. IIF captures cascading failures between sectors and is applicable only in cross-sector and aggregated analyses. RRA Score summarizes sector-specific or system-wide performance by integrating DRI, REI, and IIF.

4.7. Model Output

The RRA model produces a range of decision-support outputs, including:

- Time-series graphs of risk and resilience fluctuations (scores) that illustrate degradation and recovery trends.
- Spatial sectoral impact heatmaps visualizing the geographic spread of disruptions, including affected areas and infrastructure density.
- Comparative risk-resilience profiles for cross-sector comparisons over time, focusing on the energy and digital sectors.
- Event summary reports for decision support during and after crises, highlighting key system failures and recovery actions at each time point.

4.8. Scalability and Adaptability

The model is highly adaptable to various urban contexts and hazard scenarios, making it suitable for future smart city applications.

While currently focused on flood-related disruptions within the energy and digital sectors, the architecture allows easy extension to other types of hazards, sectors, or geographical areas. New data sources, such as those from operators or infrastructure agencies, can be integrated in future phases, alongside existing IoT and publicly available open data.

Its modular design, data-agnostic processing capabilities, and reliance on open data make it a promising tool for embedding risk and resilience thinking into smart city planning and real-time crisis management. The model's outputs are designed for potential integration into smart city platforms, emergency control rooms, or urban planning tools, including early warning systems, situational dashboards, and digital twin interfaces for simulation and decision support.

5. Case Evaluation: Floods of August 2023 in the Northeastern Part of Slovenia

The RRA model was evaluated using the August 2023 flood event in northeastern Slovenia, focusing on the energy and digital sectors. Primary event data was derived from unstructured sources, including government reports, weather data, and public databases (GOV, 2023; Polajnar, 2023; GOV, 2024; Meteo, 2023; ARSO, 2023; eVode, 2023; Ujma, 2024; SURS, 2025). Additionally, generative AI tools were employed to support data extraction and interpretation (Copilot, 2025; OpenAI, 2025).

5.1. Time, Area and Essential Services Evaluation

The evaluation period extends from August 3, 2023, at 12:00 to August 8, 2023, at 12:00, with measurements recorded every 12 hours, yielding 12 distinct time points for analysis.

The floods primarily affected areas within the Savinja, Drava, Meža, Mislinja, and Paka river basins.

The Savinja region, home to a significant share of the affected municipalities, has an estimated population of 100,000 out of Slovenia's total population of approximately 2.1 million.

The energy network in the affected areas operates at multiple voltage levels: 400 kV (operated by the Transmission System Operator – TSO, ELES), 110 kV (regional substations), and 20 kV (local distribution substations managed by Distribution System Operators – DSO, including ELES and Elektro Celje).

Table 4. Most affected municipalities by river basin within the focus area

River Basin	Municipalities (in basin)	Key Tributaries
Savinja	Žalec, Mozirje, Nazarje, Ljubno, Luče, Rečica ob Savinji, Braslovče	Dreta, Lučnica, Rečica, Homovška, Ložnica, Ljubnica, Žekovec, Trnavska
Drava	Dravograd, Vuzenica	Meža, Mislinja, Cerkvenica
Meža	Mežica, Prevalje, Črna na Koroškem, Ravne na Koroškem	Šumec, Strojna, Javorski potok
Mislinja	Slovenj Gradec, Mislinja	Suhodolnica, Završnica
Paka	Šoštanj, Šmartno ob Paki	Topličnica, Šmartnica

The network structure by station type and voltage level is as follows:

- 400 kV (TSO, generation): Šoštanj
- 110 kV (regional substations): Nazarje, Mozirje, Šmartno ob Paki, Velenje
- 20 kV (local distribution substations): Smaller municipalities, including Solčava, Luče, Gornji Grad, Ljubno ob Savinji, and Rečica ob Savinji

The energy sector in this area is dominated by low- to medium-voltage networks managed by regional DSOs. Several critical transformer stations (TSAs) in flood-prone valleys, such as Mozirje and Nazarje, were heavily impacted. Substations located near rivers were particularly vulnerable to inundation.

In the digital sector, mobile SIM penetration is approximately 130% (around 130,000 users), with nearly 100% 4G coverage. The network typically consists of backbone optical fiber lines along road corridors and mobile towers (3G/4G/5G) situated on elevated but sometimes isolated sites. Critical network hubs are located in Ravne, Žalec, and Dravograd.

Table 4 provides a detailed breakdown of the municipalities most severely impacted in each basin.

The following assumptions are made regarding infrastructure and potential downtime due to flooding:

- Fiber optic backhaul: Approximately 2–3 km per municipality, often co-located with road and river corridors, making it vulnerable to washouts.
- Fixed broadband connections: With 60–80% Fiber-to-the-Premise (FTTP) coverage, an estimated 60,000–80,000 residents have fixed broadband access.
- Mobile base stations: Typically 1–2 towers per municipality, heavily dependent on continuous power. Outages occur when backup batteries or generators are exhausted.

5.2. Methodology and Metrics Key Points

Sectoral impacts and assumed failures:

- High-voltage substations (110/400 kV): Critical nodes are prioritized; downtime typically 6–12 hours if affected.
- 11 kV and 20 kV substations: Estimated downtime is 24 hours when flooded.
- Energy recovery depends on digital networks: Remote monitoring and control require functional communications links.
- Fiber optic lines: Downtime is assumed to be 24 hours for every 2 km of flooded cable.
- Mobile stations: Expected downtime is 12 hours per flood event if power is lost.
- Mobile towers and fiber amplifiers: Fail when backup power (4–8 hours battery or generator) is depleted.

Each time point in the flood event was evaluated using four KPIs, each ranging from 0 to 1:

- DRI: Measures how disruptions in one sector (energy or digital) affect the other. Calculated as hazard intensity multiplied by exposure level.
- REI: Measures real-time risk severity, reflecting hazard intensity and infrastructure exposure. Calculated as one minus actual downtime (in hours) divided by max expected downtime (in hours).
- IIF: Evaluates the sector's capability to absorb and recover. Calculated as the number of affected infrastructure dependencies divided by the total number of critical dependencies.
- RRA: Aggregated system health score combining the other three metrics. It is calculated as: $RRA=1-[(IIF\times0.4)+(DRI\times0.3)+((1-REI)\times0.3)]$

5.3. Sectoral and Cross-Sector Flood Event Evaluation

Analysis of the August 2023 floods for the focused area is presented. At each time point, the situation on the ground and key developments in the energy sector and the digital sector are documented.

Table 5. RRA model key insights for given case

#	Date & Time	Municipalities	Hazard Context (short summary)	Energy Key Points	Digital Key Points
1	Aug 3, 12:00	All	ARSO red alert issued; rising river levels	Stable, warnings issued	Stable
2	Aug 4, 00:00	Luče, Mežica, Dravograd	Flash floods initiated, outages starting	Power outages begin	Mobile degradation begins
3	Aug 4, 12:00	All, severe: Luče, Mežica, Nazarje, Mozirje	Severe flooding, 16,000 without power	Major outages (Luče, Mežica)	Mobile networks fail significantly
4	Aug 5, 00:00	Slovenj Gradec, Prevalje, Črna, Ravne	Peak flooding, landslides, grid instability	Full outages, cascading grid failure	Critical fiber lines disrupted
5	Aug 5, 12:00	Mežica, Prevalje, Slovenj Gradec	Emergency interventions start, generators deployed	Partial energy restoration begins	Partial mobile restoration
6	Aug 6, 00:00	Vuzenica, Dravograd; Luče & Rečica still critical	Cleanup efforts, temporary electricity	Temporary restoration efforts	Continued instability in mountainous areas
7	Aug 6, 12:00	Ravne, Prevalje	Cleanup; infrastructure at risk from dried debris	Ongoing repairs; risk from debris	Fiber & mobile partially restored
8	Aug 7, 00:00	Črna na Koroškem, Mežica, Rečica ob Savinji	International aid arrives	Significant external support initiated	Gradual improvement, connectivity still limited
9	Aug 7, 12:00	Nazarje, Mozirje, Ljubno, Mislinja, Vuzenica	Stabilization phase starts	Grid stabilization	Major improvements, digital restoration
10	Aug 8, 00:00	Prevalje, Šoštanj	Modular bridges installed	Energy mostly restored urban, rural ongoing	Digital mostly restored
11	Aug 8, 12:00	All	Majority restored, long-term resilience focus	Partial restoration everywhere	Majority connectivity restored
12	Aug 9, 00:00	Majority	Post-event review	Operational; assessment	Networks stable; reporting

Table 5 presents the event log during the flooding, focusing on each sector. Figure 2 shows the RRA score at each time point. The high-level analysis indicates that the DRI peaks at TP4 (night of 4–5 August) and remains elevated through TP5 before beginning to decline. The REI reaches its lowest point around TP3–TP4 and starts to recover from TP6 onward. The IIF, which reflects cascading failures from the energy sector to the digital sector, is strongest between TP3 and TP5. The aggregated RRA score bottoms out around TP4–TP5 and then gradually trends upward as recovery efforts progress.

Regarding TP4, which is a critical point, it can be seen that the IIF is 0.9, indicating severe mutual dependency failures. The DRI reaches its maximum risk value of 0.95, while the REI is at a low 0.2 due to extensive damage. The resulting RRA score is calculated as: RRA = 1 − (0.9 × 0.4 + 0.95 × 0.3 + 0.8 × 0.3) = 0.32, thus indicating a critical system state.

5.4. Discussion

The multi-sectoral RRA model effectively captured the temporal and spatial degradation and evolving impacts of the August 2023 floods on energy and digital infrastructures.

It identified peak vulnerabilities, cascading failures, and recovery differences across the 17 municipalities, demonstrating its value for disaster response and resilience planning

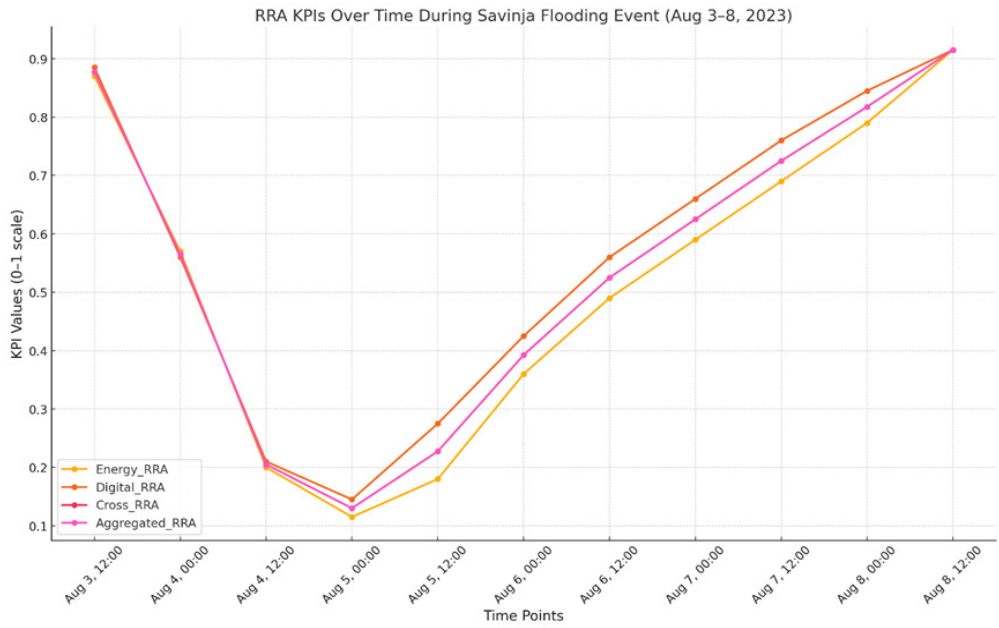


Figure 2. RRA score evaluation for the flood event case study

Table 6. RRA model key insights for given case

Layer	Key conclusions
Energy	- Critical points were identified, such as the Celje substation and Ljubno BTS. - Severe early outages occurred in Mežica, Prevalje, and Nazarje, whereas Šoštanj and Žalec demonstrated greater resilience due to elevated infrastructure and system redundancy. - Energy networks experienced sharp but shorter disruptions compared to other sectors. - REI indicated a stronger rebound in the energy sector, driven by prioritized restoration efforts. - Restoration times varied widely, with some areas experiencing outages lasting over 48 hours. - Multiple substations, particularly those in floodplains, were submerged, causing regional blackouts. - Power outages affected more than 20,000 users. - Backup systems were limited in rural areas, prolonging service disruptions.
Digital	- Digital services experienced slower failure onset and longer recovery periods. - Mobile and internet services were disrupted by power loss and damaged infrastructure. - Emergency communications surged, straining available bandwidth. - Service degradation mirrored that of the energy sector but recovery was slower due to power dependency. - Base stations lost power from grid failures, and optical infrastructure in flood zones was damaged. - Outages lasted up to 48 hours in some areas, significantly hindering emergency communications.
Cross- Sector	- Dependency trees revealed how failures in the electricity network propagated to mobile services. - Time-series analysis and cascading failure mapping (e.g., power outages triggering digital outages) closely aligned with field reports, validating the model's accuracy. - Hospitals without internet connectivity lost access to e-health systems - Citizens were unable to receive flood warnings and public safety notifications. - IIF revealed a strong correlation between energy outages and digital service disruptions. - The digital sector showed slightly higher absorptive capacity but remained heavily dependent on energy systems. - The IIF metric was crucial for identifying and modeling cascading risks between sectors, underscoring the importance of interdependency-focused planning.
Aggregated	- Reliance on unstructured public data introduces variability and potential data gaps. - The model is retrospective; real-time application would require automated data ingestion and processing. - Data quality remains a key limitation, as the model depends on variable sources. - The RRA metric provides a quantifiable, time-dependent view of resilience and has the potential to support real-time risk-informed decision-making frameworks. - DRI peaked at T5, reflecting simultaneous failures in both sectors. - Digital infrastructure recovered more slowly due to fiber repair times and dependency on energy for mobile sites, while energy services stabilized faster with generator backups. - Urban municipalities (Žalec, Slovenj Gradec) showed faster resilience curves due to redundancy and alternative routing. - Mountain-valley municipalities (Luče, Rečica ob Savinji) experienced prolonged degradation because of geographical isolation. - Combining structured and unstructured data enabled dynamic tracking of disruption and recovery patterns.

As cities become more data-driven, the need for multi-sectoral resilience models grows. Table 6 summarizes the key insights across sectoral layers, forming a basis for future improvements and broader use of the RRA model.

6. Conclusion

The increasing frequency and impact of natural disasters, such as floods, demand a more integrated and dynamic approach to urban resilience, particularly within smart city frameworks. This paper introduced a multi-sectoral risk and resilience assessment model (RRA) focused on the energy and digital sectors, which are two critical components of any smart city infrastructure. Through the case study of the August 2023 floods in north-eastern Slovenia, the model demonstrated its capability to evaluate risk and resilience over time, using publicly available unstructured data and a 12-hour time granulation. The evaluation confirmed that incorporating temporal dynamics and cross-sectoral dependencies enables a more accurate understanding of system vulnerabilities and adaptive capacities. These insights offer valuable guidance for urban planners, policymakers, and system designers seeking to create more resilient and responsive smart cities.

Future work will focus on refining the model by improving the quality of existing data, integrating additional data sources, enabling the processing of a larger number of time points, also for an even longer period. The future challenge will also be to further improve the method of calculating the RRA metrics. Ultimately, this research lays a strong foundation for implementing a comprehensive, real-time decision support system and digital twin to better prepare for and respond to natural events within smart urban environments.

Acknowledgements

The research presented in this paper is a part of the research activity of the ENDURANCE project, which is funded by the European Union's Horizon Europe research and innovation program under grant agreement No. 101168007.

References

1. ARSO. (2023). Izjemne poplave v Sloveniji med 4. in 8. avgustom 2023 [Hydrological event report]. Urad za meteorologijo, hidrologijo in oceanografijo. Available at: https://www.arso.gov.si/vode/poro%C4%8Dila%20in%20publikacije/Porocilo_visoke_vode_in_poplave_avg2023.pdf. Accessed: 20/07/2025.
2. Buldyrev, S. V., Parshani, R., Paul, G., Stanley, H. E., & Havlin, S. (2010). Catastrophic cascade of failures in interdependent networks. Nature, 464(7291), 1025–1028. Available at: https://doi.org/10.1038/nature08932. Accessed: 20/07/2025.
3. Copilot. (2025). AI-generated content using Copilot (Version July 2025). Microsoft Copilot. Available at: https://copilot.microsoft.com/. Accessed: 20/07/2025.
4. Department for Business innovation & Skills. (2013). Global Innovators: International Case Studies on Smart Cities Smart Cities Study (Bis research paper no. 135). Available at: https://www.gov.uk/government/publications/smart-cities-international-case-studies-global-innovators. Accessed: 05/07/2019.
5. Endurance Project. (2025). ENDURANCE: Strengthening the resilience of Europe's critical infrastructures (Horizon Europe, Grant Agreement No. 101168007). Available at: https://endurance-horizon.eu/. Accessed: 20/07/2025.

6. eVode. (2023). Poplave 2023: Sanacijski načrt in stanje infrastrukture [Interactive web platform]. Available at: https://poplave2023.evode.si/. Accessed: 20/07/2025.
7. GOV. (2023). Hidrometeorološko poročilo: Nalivi in obilne padavine ter povodenj v Sloveniji med 3. in 8. avgustom 2023 [Hydrometeorological report]. Vlada Republike Slovenije. Available at: https://www.gov.si/assets/vlada/Seja-vlade-SZJ/2023/10-2023/SSEUp2.pdf. Accessed: 20/07/2025.
8. GOV. (2024, July 30). Poplave v avgustu 2023 [Floods in August 2023]. Portal GOV.SI. Available at: https://www.gov.si/novice/2024-07-30-poplave-v-avgustu-2023/. Accessed: 20/07/2025.
9. Grasic, V., Kos, A., Mileva-Boshkoska, B. (2018). Classification of incoming calls for the capital city of Slovenia smart city 112 public safety system using open Internet of Things data. International Journal of Distributed Sensor Networks. 14(9). Available at: https://journals.sagepub.com/doi/full/10.1177/1550147718801703. Accessed: 05/08/2022.
10. Grašič, V., Robnik, A. (2022). Increasing resilience and resistance of Smart Cities by forecasting the number of incoming emergency calls based on IoT open data. EENA Conference. 27-29 April 2022, Marseille, France.
11. Hosseini, S., Barker, K., & Ramirez-Marquez, J. E. (2016). A review of definitions and measures of system resilience. Reliability Engineering & System Safety, 145, 47–61. Available at: https://doi.org/10.1016/j.ress.2015.08.006. Accessed: 20/07/2025.
12. Linkov, I., Trump, B. D., & Wagner, C. M. (2014). The frameworks of resilience planning and engineering. Environment Systems and Decisions, 34(4), 517–527.
13. Linkov, I., & Trump, B. D. (2019). The science and practice of resilience. Springer. Available at: https://doi.org/10.1007/978-3-030-04565-4. Accessed: 20/07/2025.
14. Mentges, A., Halekotte, L., Schneider, M., Demmer, T., & Lichte, D. (2023). A resilience glossary shaped by context: Reviewing resilience-related terms for critical infrastructures. International Journal of Disaster Risk Reduction, 96, 103893. Available at: https://doi.org/10.1016/j.ijdrr.2023.103893. Accessed: 20/07/2025.
15. Meteo. (2023). Nalivi in obilne padavine od 3. do 6. avgusta 2023 [Report on extreme rainfall and floods]. ARSO Meteorology and Hydrology Service. Available at: https://meteo.arso.gov.si/uploads/probase/www/climate/text/sl/weather_events/padavine_3-6avg2023_v29sep2023.pdf. Accessed: 20/07/2025.
16. Meteo.si (2025). Slovenian Environmental Agency. Available at: https://meteo.arso.gov.si. Accessed: 25/07/2025.
17. OpenAI. (2025). *ChatGPT* (July 2025 version). ChatGPT-4.5. Available at: https://chat.openai.com. Accessed: 20/07/2025.
18. Ouyang, M. (2014). Review on modeling and simulation of interdependent critical infrastructure systems. Reliability Engineering & System Safety, 121, 43–60. Available at: https://doi.org/10.1016/j.ress.2013.06.040. Accessed: 20/07/2025.
19. Picon, A. (2015). Smart Cities: A Spatialised Intelligence, Chichester. England. Wiley.
20. Polajnar, J. (2023, November 30). Poplave 2023. Geografske večernice. Društvo učiteljev geografije Slovenije. Available at: https://www.drustvo-dugs.si/files/2023/12/Geografske-vecernice-30-nov-2023-Polajnar.pdf. Accessed: 20/07/2025.
21. Rinaldi, S. M., Peerenboom, J. P., & Kelly, T. K. (2001). Identifying, understanding, and analyzing critical infrastructure interdependencies. IEEE Control Systems Magazine, 21(6), 11–25. Available at: https://doi.org/10.1109/37.969131. Accessed: 20/07/2025.
22. SURS. (2025). SURS (Stat.si). Statistični urad Republike Slovenije. Available at: https://www.stat.si/. Accessed: 20/07/2025.
23. Ujma. (2024). Poplave leta 2023: Poročilo Urada za meteorologijo, hidrologijo in oceanografijo. Ujma (številka 38/2024): Zgodovinski časopis (online report review). Available at: https://ojs-gr.zrc-sazu.si/ujma/article/view/9388. Accessed: 20/07/2025.

doc. dr. sc. Kasim Bajramović, dipl. ing. rud.[1]
Irhad Bajramović, BA ing. inf. teh.[2]
Irfan Bajramović, BA ing. traff.[3]

Professional paper

APPLICATION OF THE WOODWARD PROTECH 203 SAFETY SPEED CONTROLLER IN THERMAL POWER PLANTS

Abstract

The outdated mechanical-hydraulic speed safety systems used in Thermal Power Plants are being replaced by new fully autonomous three-channel electronic speed protection (safety speed regulators) WOODWARD PROTECH 203. This very accurate, fast and reliable protection works on the principle of "fail-safe" (multiple failures always lead to turbine shutdown) and its high reliability is mainly given by the use of the principle of selecting two protection channels out of three. Because it ensures the most important protected value of the turbine, it is completely independent of the function of other electronic systems of the block. The subject of the research is the protection of turbines in thermal power plants, and the paper aims to show how electronic overspeed protection (safety speed regulators) WOODWARD PROTECH 203 can improve operation, protect the turbine as one of the most important elements in the production of electricity, how automation and information technology can improve safety in thermal power plants, improve measures and actions for the prevention of occupational injuries, occupational diseases, other work-related diseases and the protection of the working environment. The implications of the results of this paper are that autonomous electronic overspeed protection ensures the protected value of the turbine in thermal power plants, which implies that the outdated mechanical-hydraulic safety protection was not optimal.

Key words: *Thermal Power Plant, Turbine, Electric Energy, Protection.*

1 PhD in Mining Engineering; Assistant Professor at the Faculty of Mechanical Engineering, University of Zenica - kasim.bajramovic@mf.unze.ba and Assistant Professor at IUT Travnik - kasim.bajramovic@iu-travnik.com
2 Bachelor-Information Technology Engineer; irhadbajramovicbajra@gmail.com
3 Bachelor road traffic Engineer; irfanbajramovic95@gmail.com

1. Introduction

Thermal power plants, as complex energy systems, contain a number of critical components, with the turbine being among the most important. Turbine reverse rotation occurs when the turbine rotor begins to rotate in the opposite direction due to backflow of steam, suction effects, or shutdown process errors. Traditional protection systems lacked sufficient accuracy and response speed, which often led to failures. ProTech 203 represents a modern solution that combines fast response, a high level of diagnostics, and the ability to automatically shut down the plant in critical situations.

The paper will present the three-channel electronic speed monitoring and protection system ProTech 203, which is located at Block 7 of the Kakanj Thermal Power Plant.

The methodology applied in the paper is a combination of technical-analytical, descriptive and comparative approaches, as it is a study of the application of a specific industrial device in real operating conditions of a thermal power plant.

Previous research and technical practice confirm the importance of digital safety controllers, such as the Woodward ProTech 203, in the modernization of thermal power plant protection systems. Several studies have focused on the application of international standards such as IEC 61508 (functional safety) and API 670 (turbine system protection), which set the framework for the design and implementation of safety controllers in power plants. In this context, devices such as the ProTech 203 and its successors (ProTech GII, SIL-3 systems) have been analyzed as a means to achieve the so-called Safety Integrity Level (SIL) requirements.

2. Functionality of ProTech 203

Woodward ProTech 203 is a three-channel electronic system for speed monitoring and protection. Each channel has its own processor, independent power supply, and speed sensor. In addition to the primary function of overspeed protection, the system includes:

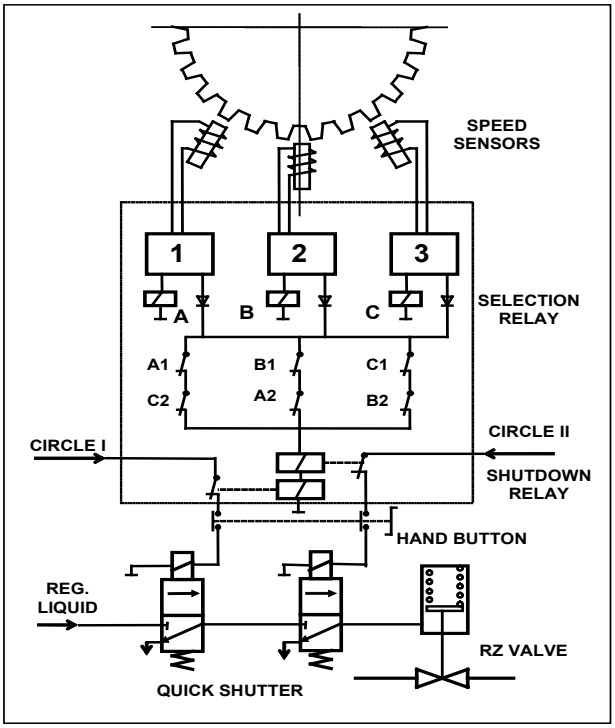
- Reverse rotation detection,
- Drive system monitoring,
- Self-diagnostics and online testing,
- Rapid relay activation in the event of a fault.

The protection function of the entire ProTech 203 system is implemented in such a way that each unit reads pulses from sensors positioned opposite the teeth of a gear rotating on the turbine rotor. When the unit determines that the safety speed threshold (3300 RPM) has been reached, it de-energizes its output relay (A, B, or C). The relay then opens its contacts (relay A opens contacts A1 and A2), which are connected within a “two-out-of-three” voting logic system. This means that if at least two units open their respective contacts, the current to the coils of the shutdown output relays is interrupted. Their contacts open, cutting power to two independent protec-

tion circuits that supply current to the electromagnetic valves of the HAWE quick shut-off system. The valves stop the flow of pressurized oil to the servo actuators of the trip valves (BZ), and at the same time, the BZ oil is released from the servo actuators to the drain, causing the BZ valves to close. (Note: The schematic of the quick shut-off system is simplified in Figure 1.)

Figure 1. The Comprehensive AI Model for Higher Education

Source: Operating instructions for the turbine "ŠKODA" K 230-16,2-P



Legend:

1, 2, 3 - Three independent electronic units

A, B, C - output relay evaluation unit 1, 2, 3

A1, A2 - starting contacts 1 and 2 of relay "A"

Figure 2. Functional diagram of ProTech 203 and BZ system applicable in Kakanj thermal power plant

Source: Operating instructions for the turbine "ŠKODA" K 230-16,2-P

3. Principle of Reverse Rotation Protection

The reverse rotation protection in the ProTech 203 is based on detecting the direction of rotation using digital pulses from speed sensors. As the device uses highly precise sensors, each of the three channels independently detects:

- The magnitude and direction of rotation
- The difference in the pulse sequence compared to a predefined reference direction

If two out of the three channels confirm that the rotation direction is opposite to the allowed one, the system triggers an alarm, activates the safety relays, and if integrated with the control system initiates an automatic shutdown or valve closure.

The Woodward ProTech 203 reverse rotation protection (electronic overspeed safety device) is a digital protection device designed to shut down the machine in the event of exceeding the maximum allowable speed. It operates with three sensors constructed on an induction principle. The signals from the sensors are fed into three identical, mutually independent units, which continuously measure machine speed and evaluate whether the set overspeed limits have been reached to trigger turbine shutdown. The shutdown relay contacts at the outputs of these three units form a logical network configured in a 2-out-of-3 voting system. A failure in one unit cannot cause a false machine trip, and in such a state, the system continues to provide full protective functionality. However, if two measurements are lost or two units fail, the machine will be shut down. (Woodward ProTech 203 – Technical Manual (Technical Manual 85196)).

Each unit independently displays the actual machine speed, stores the maximum recorded speed, and allows for testing of the preset overspeed limit during operation. The modular design enables the replacement of a single unit without interrupting the operation. Unit status indication on the front panel is provided via LED indicators and a digital display. For reverse rotation protection of the turbine, the implemented version uses negative logic and the philosophy of so-called fail-safe design. The shutdown signal for the turbine always interrupts power to the coil of the main shutdown relay. This means that in the event of a fault or power loss, the device behaves as if an overspeed condition has been detected and prevents further operation of the turbine without functional protection.

Table 1. Supply voltage

Nominal Voltage	Permissible Voltage Range	Consumption
24 V	18 - 32 V	7,25 W

Source: Operating instructions for the turbine "ŠKODA" K 230-16,2-P

The grounding conductor of the ProTech system for the power supply sources of all three units must be connected to ground. Failure to do so may result in false machine shutdowns.

4. Management of the ProTech 203 Device at the Kakanj Thermal Power Plant

Each unit of the ProTech 203 system has a touch keypad, a two-line 16-character LCD display and a potentiometer for setting the test frequency. To control the system switching to MONITOR or PROGRAM mode, there is a common switch on the front panel, which can be locked and is connected to all three units and allows locking against unauthorized interventions in the system. The ProTech 203 system consists of three units (A, B and C). Each unit has its own power supply. Each unit internally generates a voltage of +5 V and +24 V. These voltages are isolated from the input voltage. The power supply of the coil of the main stop relay +24 V (interposing relay) is conducted by all three units via dividing diodes, which ensures high reliability of the function of this relay. (Operating Instructions for turbines "Škoda" K 230 – 16.2 P; JP Elektroprivreda BiH TE Kakanj; Kakanj, February 2008).

Range of adjusted parameters

Table 2. Setting parameters

Parameter	Minimum	Maximum
TRIP SPEED SETPOINT	250 rpm	25000 rpm
MPU FAILED SETPOINT	100 rpm	25000 rpm
MPU FAILED TIMEOUT	1 s	533 min 20 s
MPU GEAR TEETH	20	120

Source: Woodward ProTech 203 – Technical Manual (Technical Manual 85196)

Possible reasons for suspension

Table 3. Reasons for suspension

MPU FREQUENCY > TRIP SETPOINT	The machine speed has exceeded the value set in the TRIP SETPOINT parameter.
OVERSPEED TEST	The machine speed exceeded the value set in the TRIP SETPOINT parameter during the test.
MPU FAIL TIMEOUT	After the reset, the revolutions did not exceed the value set in the MPU FAIL SETPOINT parameter during the time specified by the MPU FAIL TIMEOUT parameter.
MPU FAILED	Unexpected loss of signal from the speed sensor during machine operation.
NO MPU SIGNAL	The terminals at the unit input marked "Contact Input" were disconnected at the time when the revolutions fell below the minimum value defined by the MPU FAIL SETPOINT parameter.
NO RESET	The unit was not reset before re-starting or after the RPM dropped below the MPU FAIL SETPOINT.
HARDWARE FAULT	Malfunction inside the unit.
INTERLOCK FAULT	An internal cable has been disconnected.

Source: Woodward ProTech 203 – Technical Manual (Technical Manual 85196)

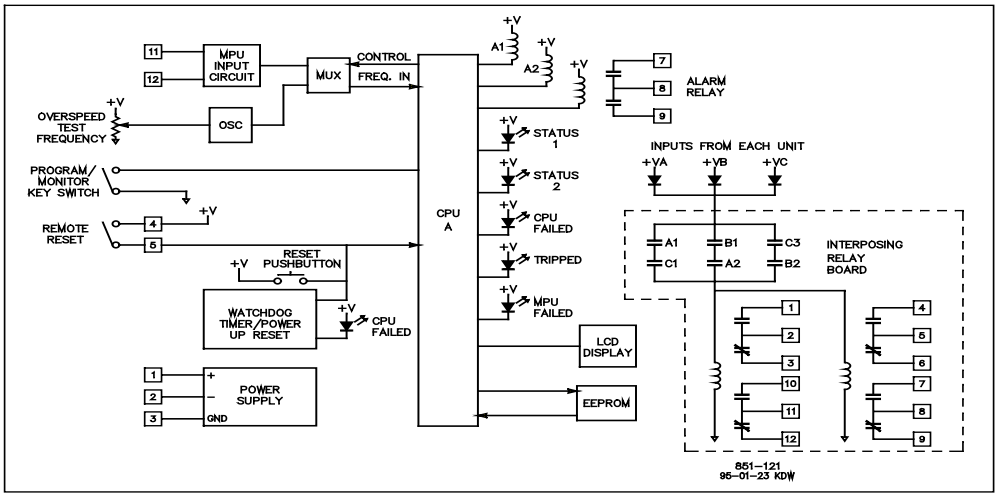


Figure 3. Block diagram of the unit and the output main relay in the Kakanj thermal power plan

Source: Operating Instructions for turbines "Škoda" K 230 – 16.2 P

The unit that has entered the suspend state remains in this state until the next reset or until the power is disconnected.

4.1. Setup and Operation of ProTech 203 at Kakanj Thermal Power Plant

The ProTech 203 system can be operated in one of two modes: MONITOR or PROGRAM. Switching to PROGRAM mode is possible only after using the key and unlocking the switch. Although the system protects the machine in both modes, it is stipulated that the device works in PROGRAM mode only during parameter setting or during its testing. After finishing the manipulation, always switch to MONITOR mode and remove the key. (Operating Instructions for turbines "Škoda" K 230 – 16.2 P; JP Elektroprivreda BiH TE Kakanj; Kakanj, February 2008).

The "MENU" key on the membrane keyboard selects the following parameters for display on the display:

- TRIP SPEED SETPOINT – set value of stop (safety) revolutions.
- MPU FAILED SETPOINT – set value of minimum revolutions (for sensor monitoring).
- MPU FAILED TIMEOUT – max. time waiting for a signal from the speed sensor after resetting the device.
- MPU GEAR TEETH – number of teeth on the gear for recording revolutions.
- TRIP ON MPU FAILURE – suspension in case of sudden loss of signal from the sensor (YES/NO – YES/NO).
- TIMER STARTS ON RESET OPTION – timer starts on reset (YES/NO).

- ALARM WHEN SPEED IS<MPU FAILED SETPOINT OPTION – alarm if the revolutions are lower than the set monitoring limit of the sensor (optional function).
- LAMP TEST – test of signal diodes.
- TRIP CAUSE - reason for suspension (if used).

PRESENT SPEED is the first parameter displayed. Each subsequent press of the MENU button causes the next parameter from the list above to be displayed. A corresponding description is also displayed for each parameter.

When the lockable switch is in the MONITOR position, the "CURSOR⇒", "ADJ⇑" and "ADJ⇑" buttons have no effect. If the lockable switch is in the PROGRAM position, a prompt appears on the display, a cursor is displayed and one of the following adjustable parameters is displayed:

- TRIP SPEED SETPOINT – set value of suspension revolutions;
- MPU FAILED SETPOINT – set value of minimum revolutions;
- MPU FAILED TIMEOUT – max. waiting time for a signal from the speed sensor after resetting the device;
- MPU GEAR TEETH – number of teeth on the gear for recording revolutions;
- TRIP ON MPU FAILURE – suspension in case of sudden loss of signal from the sensor;
- TIMER STARTS ON RESET OPTION – timer starts on reset;
- ALARM WHEN SPEED IS<MPU FAILED SETPOINT OPTION – alarm if the revolutions are lower than the set sensor monitoring limit (optional function).

If one or more of the above parameters are changed, after switching the key switch to the MONITOR position, the message CHANGES SAVED is displayed for 2 seconds.

The individual buttons work in programming mode as follows:

- "CURSOR⇒" button – moves the cursor one position to the right;
- "ADJ⇑", "ADJ⇓" buttons:
  - for whole numbers, these buttons increase or decrease the value of the number at the corresponding cursor position. For example, if the cursor is under the "0" digit of the number 5014, then pressing the "ADJ⇓" button changes the data to the value 4914;
  - for time data, the value changes according to the position of the cursor. As an example, we give the case when the cursor is under the "4" digit in the time data "1 MIN 47 SEC". By pressing the "ADJ⇑" button, the value changes to "1 MIN 57 SEC", if we press the same button again, the data on the display changes to "2 MIN 07 SEC";
  - for the "YES/NO" selection, pressing any of the "ADJ⇑", "ADJ⇓" buttons sets the opposite value;
  - if we press the "ADJ⇑" button or the "ADJ⇓" button and hold it, the numbers change again at the set speed after a short delay.

5. Programming the ProTech 203 System

Programming the ProTech 203 system consists of entering the required data for each of the parameters to be set. The programming procedure is as follows:

1. Switch the key switch to the PROGRAM position (insert the key and turn it);
2. Press the "MENU" button to set the first adjustable parameter "TRIP SPEED SETPOINT";
3. use the "CURSOR⇒", "ADJ⇑" and "ADJ⇓" buttons to enter the corresponding revolutions for stopping the machine;
4. Use the "MENU" button to move to the next adjustable parameter – MPU FAILED SETPOINT;
5. Use the "CURSOR⇒", "ADJ⇑" and "ADJ⇓" buttons to enter the corresponding revolutions for a certain value of the minimum revolutions, the achievement of which will be tested to check the correct function of the speed sensor;
6. Use the "MENU" button to move to the next adjustable parameter – MPU FAILED TIMEOUT;
7. Using the "CURSOR⇒", "ADJ⇑" and "ADJ⇓" keys, enter the corresponding time interval after which the machine should stop due to not reaching the minimum speed level;
8. Using the "MENU" key, move to the next adjustable parameter – MPU GEAR TEETH;
9. Using the "CURSOR⇒", "ADJ⇑" and "ADJ⇓" keys, enter the corresponding number of teeth on the gear for recording the machine speed;
10. Using the "MENU" key, move to the next adjustable parameter – TRIP ON MPU FAILURE;
11. Using the "CURSOR⇒", "ADJ⇑" and "ADJ⇓" keys, select "Yes" if you want the machine to stop immediately in the event of a sensor failure. "No" means that the stop will not occur;
12. Repeat this procedure on the remaining two units;
13. Return the switch back to the "MONITOR" position. The message "CHANGES SAVED" appears on the display for two seconds.
14. (Operating Instructions for turbines "Škoda" K 230 – 16.2 P; JP Elektroprivreda BiH TE Kakanj; Kakanj, February 2008).

5.1. Correct Programming of the ProTech 203

Table 4. Setup protocol

CHANNEL A	CHANNEL B	CHANNEL C
TRIP SPEED SETPOINT **3300**	TRIP SPEED SETPOINT **3300**	TRIP SPEED SETPOINT **3300**
The revolutions of the machine (rpm), at which the user wants the alarm relay to lose power, the "TRIP" LED signal light to turn on and the machine to stop.		
MPU FAILED SETPOINT **300**	MPU FAILED SETPOINT **300**	MPU FAILED SETPOINT **300**
After resetting, the machine must exceed this speed value within the time limit specified by the MPU FAILED TIMEOUT parameter, otherwise it will stop, i.e. the speed must be constantly higher than this value whenever the contact is open marked "Contact input", otherwise it will stop.		
MPU FAILED TIMEOUT **60 min 00 sec**	MPU FAILED TIMEOUT **60 min 00 sec**	MPU FAILED TIMEOUT **60 min 00 sec**
The time interval after resetting within which the machine must exceed the minimum revolutions (a signal from the revolution sensor must appear) set by the MPU FAILED SETPOINT parameter, otherwise the machine will stop.		
MPU GEAR TEATH **90**	MPU GEAR TEATH **90**	MPU GEAR TEATH **90**
Number of teeth of the gear for recording revolutions.		
TRIP ON MPU FAILED **YES**	TRIP ON MPU FAILED **YES**	TRIP ON MPU FAILED **YES**
If a loss of signal from the speed sensor occurs, the “MPU Fail” LED lights up and the alarm relay loses voltage. If the “TRIP ON MPU FAILURE” parameter is set to “Yes”, then the machine stops; this parameter is used in case of an unexpected loss of signal from the sensor during machine operation. This selection does not affect the stop due to “MPU FAILED TIMEOUT” timeout or the stop due to an open contact “Contact input”.		
TIMER STARTS ON RESET **YES**	TIMER STARTS ON RESET **YES**	TIMER STARTS ON RESET **YES**
The timer is down at the time of reset. The "START" button on the unit is not active.		
ALM IF SPD < MPU FAIL SETPT **NO**	ALM IF SPD < MPU FAIL SETPT **NO**	ALM IF SPD < MPU FAIL SETPT **NO**
THE ALARM RELAY IS NOT CONNECTED WHILE THE TIME METER IS OPERATING AT RPMS LESS THAN 300.		

Source: Operating Instructions for turbines “Škoda” K 230 – 16.2 P

6. Conclusion

The application of the Woodward ProTech 203 overspeed safety controller in the Kakanj Thermal Power Plant represents a key step toward improving the safety, reliability, and efficiency of turbine operations. This modern safety system enables precise control and real-time protection of turbines, thereby minimizing the risk of mechanical failures and accidents caused by excessive rotational speed. An analysis of the ProTech 203 device's functionalities confirms that its triple modular architecture, rapid response, and redundancy capabilities offer a significant upgrade compared to older protection systems. The integration of this device into the existing plant infrastructure at the Kakanj Thermal Power Plant contributes to the overall enhancement of automation processes and operational safety, in line with modern technical and safety standards in the energy sector. Given all of the above, it can be concluded that the implementation of the ProTech 203 controller is not merely a technical requirement but also a strategic decision. It enables long-term operational stability of thermal power capacities, reduces maintenance costs, and increases the safety of both personnel and equipment. Possible open questions for this paper: To what extent is the current protection system in thermal power plants such as TPP Kakanj really optimized for the new challenges of digitalization, automation and integration with smart grids? Is ProTech 203 sustainable in the long term in the context of increasing demands for cybersecurity and digital resilience of energy systems? Based on the current knowledge regarding the implementation of the Woodward ProTech 203 safety speed controller at the Kakanj Thermal Power Plant, future research should focus on the following key areas: Analyze the extent to which the implementation of the ProTech 203 device complies with national and international safety and environmental standards (e.g., IEC 61508, API 670), and contribute to the development of local regulations and guidelines for the protection of turbine systems in Bosnia and Herzegovina.

References

1. Operating Instructions for turbines "Škoda" K 230 – 16.2 P; JP Elektroprivreda BiH TE Kakanj; Kakanj, February 2008.
2. Woodward ProTech 203 – Installation and Operation Manual (Manual 85205); Ženeva 2018.
3. Woodward ProTech 203 – Technical Manual (Technical Manual 85196); Colorado /1/2013.
4. ISO 17359: Condition monitoring and diagnostics of machines; Ženeva 2018.
5. ISO 13849-1:2015 – Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design; Ženeva 2015.
6. ISO 12100:2010 – Safety of machinery – General principles for design – Risk assessment and risk reduction; Ženeva 2015.
7. IEC 61508 (international equivalent) – Functional safety of electrical/electronic/programmable electronic safety-related systems; Ženeva 1998 and 2015.
8. Scientific, Technical and Industrial Sources: Woodward ProTech 203 Overspeed Protection System, Model 9905 976 – technical specifications and features (e.g. response time, three sensors and "two out of three" voting.
9. Woodward's broader lines of systems – such as ProTech-GII, TPS and MicroNet – are described within the broader purpose and design improvements for thermal power plants and other industrial applications; Fort Collins, Colorado, SAD 2016.

Dr. sc. Zijad Lugavić[1]
Mr. sc. Eldina Čustović [2]
Adnedina Lugavić, dip. med. sestra[3]
Adnan Lugavić, bachelor – inžinjer elektrotehnike[4]

Professional paper

COMMUNICATION OF HEALTHCARE WORKERS WITH THE PUBLIC – WITH A SPECIAL FOCUS ON THE USE OF ICT

Abstract

This paper explores the importance of communication in healthcare, with a particular focus on its impact on treatment quality and the relationship between medical staff and patients. The aim of the research is to analyze how improving verbal and nonverbal communication, along with the application of information and communication technologies (ICT), can enhance healthcare services and reduce the risk of unintended errors in hospital settings. The research findings indicate that healthcare professionals spend a significant portion of their working hours communicating, while factors such as the increase in comorbidities, the fragmentation of healthcare services, and the growing awareness of patients further emphasize the need for more effective communication. Empathy, assertiveness, and active listening are crucial aspects of verbal communication, while nonverbal communication, including body language, plays a key role in understanding patient needs. Additionally, studies confirm that communication errors are among the leading causes of mistakes in the healthcare sector. The integration of information and communication technologies (ICT) into the healthcare system has proven to be essential for improving communication. Digital platforms, electronic medical records, telemedicine, and email communication enable faster and more accurate information exchange between medical professionals and patients. The use of ICT improves healthcare service accessibility, reduces administrative burden, and contributes to better care coordination. The paper concludes by emphasizing the need for continuous development of communication skills among healthcare professionals through education and practice, as well as the application of ICT to enhance information exchange and ensure more efficient healthcare delivery.

Key words: *Communication in Healthcare, Verbal Communication, Nonverbal Communication, ICT.*

1 docent, Grad Tuzla, ZAVNOBIH-a 11, zijad.lugavic@tuzla.ba
2 Grad Tuzla, ZAVNOBIH-a 11, eldinac@tuzla.ba
3 JZNU Dom zdravlja "Dr. Mustafa Šehović" Tuzla, Albina Herljevića 1, dinalugavic@hotmail.com
4 Personify Health, Fra Grge Martića do 42, adnanlugavic89@gmail.com

1. Introduction

Communication plays a pivotal role in healthcare. Healthcare professionals spend approximately 60% of their working time engaged in communication activities (Coiera, 2000). This includes not only exchanging information with colleagues but also informing patients about their medical condition, requesting diagnostic procedures, and coordinating various healthcare tasks.

In an ideal clinical setting, all members of the medical team would be physically present at the patient's bedside, with full access to relevant information, no external distractions, face-to-face interactions, and an actively engaged patient providing complete responses. However, reality often presents a stark contrast—communication is frequently interrupted, asynchronous, and fragmented, involving multiple types of messages, languages, media, and coding systems. Documentation is often incomplete and scattered across several platforms.

Given the rising prevalence of comorbidities, the increasing fragmentation of healthcare services, more part-time healthcare workers, and patients who are better informed and more engaged in their care, the space and need for communication will continue to grow.

American authors Bovee and Thill have analyzed the evolution of business communication, noting that communication between companies and consumers was once largely one-directional. Organizations would deliver messages to the public through mass media with limited feedback from consumers. Over time, technological advancements have enabled a more interactive, two-way, conversational model of communication (Bovee & Thill, 2012). This modern approach allows companies to engage directly with consumers and respond more effectively to their needs.

Communication processes and systems are studied within the academic field of communication studies, which explores how humans communicate, the effects of communication, and symbolic interaction (Proleksis Encyclopedia, 2025). Communication is fundamental to interpersonal relationships and significantly impacts the success of both private and professional interactions. Effective communication helps build positive impressions and strengthens relationships among employees, clients, and business partners.

Duraković (2019) identifies several forms of business communication:

- **Interpersonal communication** – focuses on interactions between individuals and their impact on relationships.
- **Small group communication** – examines communication processes within teams and organizations.
- **Language and symbolic codes** – analyzes verbal and nonverbal modes of expression.
- **Organizational communication** – studies communication within corporate structures.

- **Public communication** – involves public speaking and audience interaction.
- **Mass communication** – explores how information is transmitted through mass media.

Garača and Kadlec (2011) emphasize that communication is not merely the exchange of information but also a process of understanding and interpreting messages between sender and receiver. In this context, communication skills can be developed and refined through experience and continuous practice.

Effective communication in healthcare can improve treatment outcomes and contribute to faster patient recovery (Marković, 2008). Numerous studies have shown that communication failures are among the leading causes of adverse events and medical errors in hospitals. Since the quality of healthcare delivery heavily depends on the efficiency and effectiveness of communication processes, it is essential to improve how information is shared to maintain high standards of care.

This paper explores how communication itself can and should be used to improve communication practices in healthcare, with a particular focus on the role of information and communication technologies (ICT).

2. Foundations of Communication Skills with Emphasis on the Public Health System

Patients frequently report feeling misunderstood and undervalued in their role within healthcare delivery. Therefore, maintaining consistent communication and timely information exchange is essential to improving patient experience, fostering the development of communication skills, and advancing comprehensive quality management systems in healthcare (HEQI Institute, 2025).

Healthcare professionals should ideally acquire communication competencies during their academic education—whether in medicine, nursing, dental studies, or other specialties. Nevertheless, continual improvement and hands-on learning are crucial for ensuring effective patient interaction. For professionals to build meaningful relationships with patients, they must possess a clear understanding of their own personality and professional identity. Furthermore, they should demonstrate professionalism, self-assurance, emotional stability, openness, kindness, empathy, and strong active listening skills. Among these, empathy, listening ability, and establishing professional authority are particularly emphasized in daily practice (Lučanin & Despot Lučanin, 2010).

2.1. The Importance of Effective Communication in Healthcare

Communication is the cornerstone of human interaction and plays a vital role in revealing individual characteristics during patient encounters. Effective communication enhances patients' trust in healthcare professionals, fosters better teamwork among colleagues, and positively impacts workplace performance. It not only increases job satisfaction but also stimulates professional growth. Moreover, improved communication skills contribute to resolving conflicts

more effectively within healthcare teams, leading to increased overall productivity (Krešić, 2013).

When healthcare staff possess well-developed communication abilities—integral to a respectful and professional approach—patient interactions tend to be smoother and more efficient. Potential conflicts or differing expectations between patients and providers can be alleviated, while diagnosis, treatment, and recovery processes become more accurate and effective. In nursing, particularly, communication plays an essential role in daily responsibilities, and its enhancement directly correlates with patient satisfaction. A positive nurse-patient relationship and strong interdisciplinary teamwork rely heavily on refined communication skills, which also contribute to elevating the public perception of nurses and their societal importance.

2.2. Openness and Courtesy

In everyday patient care, healthcare providers are expected to show genuine interest in their patients' concerns and demonstrate openness—both verbally and nonverbally. Nonverbal openness may include an open body posture (e.g., avoiding crossed arms or legs), maintaining eye contact, and adopting a confident tone of voice. On the verbal side, openness begins at the very first moment of interaction—such as a warm greeting. Failing to greet a patient can create an impression of detachment, self-centeredness, or preoccupation, leaving the patient feeling neglected.

Healthcare workers should also employ both open- and closed-ended questions, interject appropriately during patient narratives, and offer relevant commentary. This behavior helps patients see medical professionals as approachable human beings. Courtesy, closely tied to respect, must be present throughout the interaction. For instance, if a nurse notices that a patient is struggling with a urinary catheter, they should offer assistance. Likewise, physicians can demonstrate care by alleviating discomfort through the prescription of suitable therapies, which are then administered by nursing staff. Respect for the patient must be upheld at all times, regardless of their condition or reason for seeking care.

2.3. Empathy

In the context of healthcare, empathy is defined as the capacity to accurately recognize and understand another person's feelings, needs, thoughts, and behaviors—and to convey that understanding in a meaningful way (Arnold & Underman Boggs, 2003; Halpern, 2003; Hojat et al., 2004).

Psychologically, empathy refers to the ability to identify with and comprehend the emotional states of others. This trait is crucial for healthcare workers to effectively understand the intensity of the problems their patients face. Empathic professionals can more readily assess emotional cues, which is particularly important in fields like psychiatry. Although empathy is desirable across all medical specialties, its development often depends on personal disposition and experience. Nurses, technicians, psychiatrists, and pediatricians tend to

display high levels of empathy due to the nature of their work involving frequent patient interaction. In contrast, surgeons—who often spend less time in direct communication with patients—may exhibit lower levels of empathetic expression (Nagpal et al., 2012).

2.3.1. Verbalizing Empathy

Empathy is a skill that can be cultivated through experience, and seasoned healthcare professionals know how to articulate it at the right time. This involves recognizing the patient's emotional state, encouraging them to express their concerns, and offering support. When expressing empathy, professionals often reflect patients' own words back to them in calming phrases—a technique known as "mirroring." This approach helps to reduce patient fear and anxiety.

For example, if a patient voices fear regarding a lumbar puncture, a healthcare provider might calmly explain that the procedure is minimally invasive and designed to avoid nerve damage. They may also describe possible side effects to foster a sense of preparedness and reassurance.

Healthcare workers must be able to detect both verbal and nonverbal signs of anxiety in their patients and respond empathetically. Nonverbal cues such as sweating, clenched fists, or fixed stares at medical equipment can be harder to detect. In dental clinics, for instance, patients often show signs of nervousness before a procedure begins. A skilled dentist will interpret these cues and take steps to further reassure the patient, even if the fear hasn't been verbally expressed (Lučanin & Despot Lučanin, 2010).

Demonstrating empathy is critical to building trust in medical relationships. If patients perceive a lack of understanding or support, they may question their treatment plan or even reject it altogether. For example, a patient might refuse a dental procedure due to insufficient explanation. Similarly, hospitalized patients may delay or decline interventions unless clearly informed about their importance.

Empathy is especially vital when caring for patients undergoing intensive treatment, such as those in hematology-oncology units. Medical staff must be able to identify signs of fear, uncertainty, and anxiety, and address them through both verbal and nonverbal means. Without empathetic engagement, patients may view the healthcare system as impersonal or uncaring, which can hinder their recovery and reduce compliance with treatment (Nagpal et al., 2012).

2.4. Assertiveness and Authority

Assertiveness is not an innate trait but rather a set of learned behaviors involving rational action, non-violent communication, respect for others, constructive social engagement, and the ability to quickly adapt and respond appropriately to varying circumstances. Lučanin and Despot Lučanin (2010) emphasize that the establishment of authority by healthcare professionals within medical institutions is achievable only through assertiveness.

Healthcare workers are ordinary individuals who possess specific skills and knowledge acquired through education and experience. However, their professional expertise does not exempt them from everyday emotional challenges. For instance, if a healthcare worker experiences a personal loss, such as the death of a parent, their emotional state may remain affected for weeks. This can influence their communication with patients and colleagues, possibly creating an impression of indifference, coldness, or unprofessionalism. Despite personal difficulties, it is crucial that healthcare professionals maintain a professional demeanor and avoid transferring personal emotions onto patients, as this can impact the quality of healthcare provided (Lučanin & Despot Lučanin, 2010).

The adaptability of healthcare workers is essential. Night shifts, which are often calmer than day shifts, can quickly change with the arrival of a patient who has sustained severe injuries in a traffic accident. In such moments, the medical team must immediately shift focus, cease informal communication, and dedicate themselves fully to emergency intervention. Conversely, if a patient arrives afterward with mild bronchitis symptoms, the healthcare staff should adjust their approach to avoid unnecessary tension and provide calm, professional care.

The proper application of assertiveness combined with empathy in healthcare practice is a key factor in building trust between patients and medical staff, ultimately contributing to higher quality care and better treatment outcomes.

2.5. Listening Skills

For an effective and rapid analysis of the information conveyed by the patient during a medical interview, healthcare professionals must possess well-developed active listening skills. Patient information should be linked to potential health issues, possible solutions, and relevant facts learned through professional training. To accelerate the interview and ensure an accurate diagnosis, the interviewer must be fully attentive to every detail the patient provides. It is vital for the healthcare worker to identify every possible health problem or concern and connect it with their expertise. Every communication initiated by the patient must be recognized and appropriately linked, enabling a more effective interview and successful diagnosis.

Listening skills play a crucial role by enabling healthcare workers to ask targeted questions that follow the patient's responses. For example, if a patient reports increased fluid intake in recent days (suggesting polydipsia), frequent urination (polyuria), persistent hunger (polyphagia), and sudden weight loss (indicative of diabetes), the healthcare worker should avoid unrelated questions such as, "Did you have chickenpox as a child?" Instead, they should ask, "When did you notice these changes? Are you taking insulin? Do you have any endocrinology reports?" Asking irrelevant or imprecise questions, or missing nonverbal cues, can lead to an unsuccessful interview and incomplete diagnosis.

Timely recognition of symptoms and nonverbal signals significantly aids accu-

rate diagnosis. Therefore, communication skills are vital for healthcare workers, who must carefully listen to patient information and respond responsibly. When communicating, healthcare workers should focus on three key aspects: what the patient says, how they say it, and the nonverbal signals they send. By employing active listening and close observation, medical staff can gather all relevant data, analyze it, and integrate it with their professional knowledge, thereby improving diagnosis and quality of care (Lučanin & Despot Lučanin, 2010).

3. The Importance of Communication Among Healthcare Workers

Medical communication represents the initial step in the collaborative treatment process. By definition, the medical interview is a conversation between healthcare provider and patient aimed at collecting pertinent patient information. This information may be conveyed through various channels, including:

- verbal,
- nonverbal,
- written,
- formal, and
- informal communication (Barker, 2003; Breakwell, 2001).

It is essential that the interview is conducted at a high professional standard by all healthcare workers, including medical technicians, nurses, general practitioners, and medical specialists. The primary goal of every medical interview is to gather patient information efficiently and thoroughly. Questions must be thoughtfully structured—never rhetorical—and purposefully directed. Properly formulated questions enable patients to answer clearly, reducing anxiety and fear that might hinder honest communication. When the interviewer asks appropriate questions, whether open or closed, the patient provides information crucial for accurate diagnosis. Besides verbal cues, interviewers must carefully monitor nonverbal signals from both patients and themselves (Barker, 2003; Breakwell, 2001).

3.1. Communication with Patients of Different Age Groups

Healthcare professionals interact with patients across different age groups and those with specific health issues, making it vital to adapt communication to each situation and individual. Below are descriptions of key patient groups commonly encountered in daily practice.

3.1.1. Communication with Elderly Patients in Healthcare

Older adults often face challenges communicating with healthcare providers, rarely asking questions or expressing their needs openly. With the increasing elderly population, adapting communication strategies is essential. According to gerontologists, old age begins at 65, with each life stage carrying distinct characteristics. Compared to younger individuals, communication with elderly patients can be hindered by sensory impairments, cognitive changes, and societal

biases towards older adults. These obstacles can adversely affect treatment outcomes, underscoring the need for careful communication with this group.

When establishing communication, it is important to assess the patient's overall functional status, including sensory capabilities, psychosocial needs, emotional state, and coping mechanisms. Some elderly patients experience heightened anxiety when visiting the doctor, which can limit open communication. Encouraging patients to write down questions and symptoms beforehand is recommended. Research shows that when doctors devote full attention to elderly patients in the first 60 seconds of the visit, patients later perceive the consultation as longer and more attentive (Brajković et al., 2011; Baker, 2004).

Effective communication with older patients involves active listening, allowing them to express thoughts without interruption, and avoiding medical jargon. It is advisable to provide written instructions and summaries of examinations to ensure clarity. Speaking slowly, clearly, and loudly enough is crucial, along with confirming patient understanding by having them repeat instructions. Additionally, patients should be given opportunities to ask further questions and express feelings. Family members often participate in elderly patient care, facilitating better understanding of diagnoses and adequate support (Brajković et al., 2011).

3.1.2. Communication with Children and Adolescents

Pediatrics is a medical field where communication is critical, involving not only children but also their parents. It is important to explain medical procedures to children in a clear, age-appropriate manner, requiring patience and empathy. Parents have the right to be fully informed about their child's health and upcoming medical tests.

Pediatric care uniquely involves active family participation, especially by parents. The knowledge that a child is ill causes stress and concern throughout the family. Healthcare professionals face the challenge of conveying information to parents, where the manner of delivery is crucial. Parents may experience shock and emotional vulnerability but must find ways to cope. The communication style significantly influences the treatment process and the parents' ability to adjust. Building a good relationship with the family starts with effective communication, which should:

- Provide accurate and clear information,
- Allow parents to express emotions and reduce stress,
- Help understand the illness and treatment process,
- Offer psychological support to parents (Grubić et al., 2011).

Successful communication requires:

- Strong communication skills,
- Active listening and demonstrated interest,
- Correct transmission of information and instructions,

- Tailoring the approach to the needs of both parents and child (Grubić et al., 2011).

Understanding parents' emotional states and reactions is key. Quality support helps achieve the main treatment goals, including:

- Assisting parents in adjusting to the child's illness,
- Reducing or preventing psychological consequences,
- Enabling parents to provide proper care,
- Helping the child understand their condition to ensure the best possible quality of life (Grubić et al., 2011).

A child's adaptation to hospitalization and reduction of negative effects depend heavily on effective communication between healthcare workers and children. Nurses play a central role, supported by teamwork with other medical staff. Older children and adolescents usually require only verbal explanations, while younger children need communication methods suited to their developmental stage and abilities (Havelka, 2016).

3.1.3. Communication with Blind and Deaf Individuals

People with hearing or vision impairments require a specialized communication approach, but it is essential to ensure they do not feel isolated or treated differently from others. Healthcare professionals, including nurses and technicians, frequently interact with individuals with such disabilities, making it crucial to assess their communication abilities and preferences.

For individuals who are deaf or hard of hearing, providing paper and pen for written communication is helpful if neither party knows sign language. Many hearing-impaired individuals can read lips, so speaking clearly, slowly, and articulating words properly is important to aid comprehension. If the healthcare worker is proficient in sign language, it can greatly enhance communication quality. It is vital to adapt to the communication style the patient is accustomed to.

In the case of blind individuals, communication is not usually a technical issue, but they may feel uncomfortable because they cannot see the interlocutor. Therefore, healthcare workers should always introduce themselves upon entering the room, stating their full name and professional title. For example: "Good day, Mrs. M.M. I am your nurse/technician, and with your permission, I will now measure your blood pressure." This approach helps the patient recognize the voice and connect the person with their healthcare role.

Additionally, it is important to explain every medical procedure in detail, step by step, so the patient understands what is happening. Since blind patients cannot rely on nonverbal cues, the tone of the healthcare worker's voice becomes crucial for conveying emotions and intentions.

When blindness is recent, patients need support during their adjustment process. Motivation plays a key role in achieving economic independence, and re-

training may sometimes be necessary to enable the individual to continue professional work despite vision loss. Adaptation is considered successful when the patient accepts the new reality and develops motivation to change their lifestyle (Havelka, 2016).

3.2. Therapeutic Effects of Group Therapy

A significant part of private and professional life occurs within groups, where communication is essential for shaping interpersonal relationships. Actively involving all participants in communication encourages interaction and ensures messages are clear and understood by everyone.

Although a message may be intentionally addressed to a particular group member, it simultaneously becomes accessible to others, who interpret it through words, context, tone, pace of speech, expression style, eye contact, and body language.

Groups vary by the number of participants, classified as:

- Small groups – up to 12 members,
- Medium groups – between 13 and 20 or 25 members,
- Large groups – more than 25 participants (Bilić, 2011).

Communication within groups has a strong therapeutic effect because it provides insight into individuals' defense mechanisms, encourages expression of emotions and thoughts, and activates participants. Taking part in group sessions offers new experiences and valuable social interaction. A crucial therapeutic factor in group therapy is fostering a sense of belonging, which gives patients feelings of value and usefulness.

This approach is particularly important for psychotic patients. For them, feeling accepted and acknowledged within the group has a profoundly therapeutic impact. These patients often feel neglected, worthless, and isolated; thus, simply knowing they are seen and that their presence matters can greatly improve their emotional well-being (Klain et al., 2007).

The group therapist plays a key role by guiding communication within the group and creating a space where patients can freely express thoughts and feelings. Early in therapy, patients mostly address the therapist, but as the process continues, communication becomes more dynamic and shifts to interactions among group members. Sometimes intense discussions may arise, which are a natural part of group dynamics.

A challenge in group therapy is ensuring active participation by all patients. Some participants tend to dominate conversations, which can limit others' opportunities to express themselves. In such cases, the therapist adjusts the session flow and may extend the duration to allow everyone a chance to contribute (Klain et al., 2007).

4. The Role of ICT in Healthcare Communication

Communication between patients and healthcare institutions via phone, email, and digital platforms is increasingly common in modern healthcare systems, offering numerous advantages as well as challenges.

4.1. Telephone Communication

Telephone communication plays a vital role in contemporary healthcare, providing patients with a quick and convenient way to contact medical staff for inquiries, appointment scheduling, or urgent information (Curtis & Evens, 1989). It offers direct access to healthcare workers, which is especially important when immediate medical advice or support is needed.

One of the main advantages of telephone communication is its accessibility and ease of use. Patients can rapidly reach healthcare facilities to resolve health concerns. Many medical services offer 24-hour phone support, allowing patients to access information anytime (Perry et al., 2001). However, the absence of visual contact can be challenging, especially when discussing complex medical topics or when detailed explanations are required (Müller et al., 2018).

Despite these limitations, telephone communication remains an indispensable tool in healthcare, enabling efficient and rapid patient access to medical information and support. To maximize its effectiveness, healthcare providers must be adequately trained to deliver clear, precise information and continuously improve telephone communication skills (Sheehan et al., 2021).

4.2. Email Communication

Email communication is gaining importance as a simple and effective method for exchanging information between patients and medical staff. It allows patients to receive advice and instructions from home. This method is useful for non-urgent questions, submitting test results, or seeking guidance for ongoing treatment without phone calls or visits to healthcare facilities (Ye et al., 2010).

A major advantage of email is its flexibility and availability. Patients can send inquiries at convenient times, regardless of medical staff working hours. This is particularly beneficial for those with less urgent health issues or living far from healthcare centers. Nevertheless, email communication poses challenges related to data privacy and security. The lack of immediate contact may result in delayed responses or misunderstandings, especially for complex medical issues (White et al., 2004).

Therefore, healthcare institutions must ensure secure email systems and provide patients with clear guidelines on proper use for medical purposes.

4.3. Communication via Digital Platforms and Telemedicine

The use of digital tools, such as online portals and communication apps, is becoming integral to modern healthcare. Telemedicine stands out as a key form

of digital communication in medicine, enabling patients to access medical services via the internet. This includes virtual consultations, health monitoring through mobile apps, and viewing lab results on online platforms. Advances in digital technology significantly improve healthcare accessibility, with research confirming the positive impact of telemedicine on patients and healthcare systems (Waller & Stotler, 2018).

Studies show that virtual consultations are as effective as traditional ones, particularly in primary care, psychiatry, and chronic disease management (Marco-Ibáñez et al., 2023). Before widespread adoption of digital tech in healthcare, virtual care often took place through virtual clinics using various communication tools like phone and video calls, especially beneficial for remote populations. These efforts focused mainly on public health, prevention, and diagnosis.

The COVID-19 pandemic accelerated the adoption of virtual care models. Today, digital healthcare solutions are common in emergencies and routine treatments. Their primary role is to reduce infection spread while conserving resources such as protective medical equipment (Støme et al., 2021). Integrating telemedicine has proven crucial for continuous medical service delivery, especially during crises. It allows healthcare workers to provide essential care remotely, decreasing physical contact and easing the burden on facilities.

Digital platforms provide patients better access to their medical data, test results, and appointments, offering greater control over their health. They also facilitate disease management and improve transparency in medical processes, building patient trust in the healthcare system (Paul et al., 2023). Clear presentation of diagnoses, treatment plans, and procedures helps patients feel informed and actively involved in health decisions. This approach strengthens collaboration between patients and medical staff, enhancing healthcare quality.

While digital platforms offer many benefits, ensuring their security and user-friendliness is vital to make them accessible to all users.

5. Conclusion

Communication forms the foundation of every interaction, linking the sender and receiver in the exchange of thoughts, emotions, and needs. It is essential not only for conveying information but also for building trust, understanding, and emotional support. For communication to be effective, it must integrate both verbal and nonverbal elements, since a significant portion of messages is conveyed through tone of voice, facial expressions, and body language.

For healthcare professionals, especially nurses and medical technicians, well-developed communication skills are not merely tools—they are fundamental to delivering successful patient care. Every conversation, approach, and conclusion of an interaction can shape a patient's experience and their trust in the healthcare system. While patients may not always remember the technical precision of medical procedures, they will recall the warmth, attention, and understanding they received.

Special consideration must be given to vulnerable patient groups such as the elderly, children, individuals with disabilities, psychiatric patients, and those receiving palliative care. Tailoring communication methods to each individual not only facilitates treatment but also enhances patients' quality of life. Active listening, empathy, and patience are not just desirable traits; they are essential for establishing trust and fostering a successful patient-provider relationship.

There is a noted preference for electronic forms of communication, particularly email, though challenges remain, including difficulties in understanding medical information and delays in response times. Therefore, investing in education and modern ICT, along with improving communication skills, is critical for every healthcare worker. Professional and compassionate communication not only contributes to high-quality healthcare but also positions healthcare workers as the best ambassadors of their profession and key promoters of healthcare institutions.

The conclusion of this study clearly highlights the ongoing need for healthcare professionals to continuously enhance their communication skills and integrate contemporary digital tools into the healthcare delivery process. It is crucial to adapt communication strategies to the preferences of different patient age groups to ensure effective and quality communication. Ultimately, effective communication is not merely a tool—it embodies the very essence of humanity within the medical profession.

Despite the valuable insights offered, this study is subject to several limitations:

- **Lack of empirical data**: The conclusions are primarily based on theoretical and observational insights, rather than quantitative or qualitative data collected through fieldwork or patient surveys.
- **Generalization across healthcare settings**: The study assumes a uniform healthcare context, potentially overlooking variations in communication practices across different institutions, regions, or healthcare systems.
- **Technological scope**: While digital tools such as email are mentioned, the analysis does not explore the broader landscape of emerging communication technologies like telemedicine, mobile apps, or AI-based platforms.
- **Patient perspective**: The emphasis is placed largely on healthcare providers, with limited attention given to patients' experiences, preferences, and perceptions of communication.

Open Questions for Future Analysis

- How do patients from different demographic and cultural backgrounds perceive and evaluate healthcare communication?
- What is the measurable impact of digital communication tools on patient satisfaction and health outcomes?
- How do specific nonverbal communication techniques influence trust-building among vulnerable patient groups?

- What training methods are most effective in developing and sustaining communication competencies among healthcare professionals?

Recommendations for Further Research:

- Conduct empirical studies involving both healthcare professionals and patients to assess the effectiveness of specific communication strategies and tools.
- Explore the integration of emerging technologies (e.g., AI-driven chatbots, teleconsultation platforms) into patient-provider communication frameworks.
- Develop patient-centered models for communication that reflect cultural, emotional, and psychological dimensions.
- Evaluate training programs designed to improve communication skills among nurses and medical technicians, with an emphasis on both verbal and nonverbal competencies.

Scientific Claims:

- Effective communication is a core competency in healthcare and significantly influences patient trust, satisfaction, and overall care experience.
- Nonverbal cues such as tone of voice, facial expressions, and body language carry substantial communicative weight and are essential for quality patient interaction.
- Tailored communication with vulnerable groups enhances their quality of life and facilitates more effective treatment.
- The integration of modern digital tools and continuous communication training is crucial to meet the evolving demands of diverse patient populations.
- Professional and compassionate communication defines not only the quality of healthcare delivery but also the ethical and humanistic values of the medical profession.

References

1. Arnold, E., Underman Boggs, K. (2003). Interpersonal relationships: Professional communication skills for nurses. St Louis: Saunders.
2. Baker SK. (2004). Thirty ways to make your practice more patient-frendly. In:Woods D, ed. Communication for Doctors: How to Improve Patient Care and Minimize Legal Risk. Oxford: Radcliffe.
3. Barker, P. (2003). Interviewing as craft. U P. Barker (ur), Psychiatric and mental health nursing (76-86). London: Hodder Arnold.
4. Bilić V. (2011). Komunikacija u grupi. Medix.2011; Supl 1:84-6.
5. Bovee, C. L. i Thill, J. (2012). Suvremena poslovna komunikacija, MATE, Zagreb, str. 3.
6. Brajković L, Ratković AS, Ivkić G. (2011). Komunikacija s osobama treće životne dobi.Medix.2011;Supl 1:51-4.
7. Breakwell, G. (2001). Vještine vođenja intervjua. Jastrebarsko: Naklada Slap.
8. Coiera, E. (2000). When Conversation is better than computation, Journal American Medical Informatics Association, 7, 277-286.
9. Curtis, P. & Evens, S. (1989). Doctor-patient communication on the telephone. Canadian Family Physician, 35, 123.

10. Duraković, J. (2019). Poslovno komuniciranje u novomedijskom okruženju. Univerzitet u Sarajevu, Fakultet političkih nauka.
11. Garača, N. i Kadlec, Ž. (2011). Komunikacija u procesu menadžmenta, Practical management: journal of management in theory and practice, Virovitica, str. 120.
12. Grubić M, Bogdanić A, Kniewald H, Filipović-Grčić B. (2011). Komunikacija u pedijatriji. Medix.2011; Supl 1:44-6.
13. Halpern J, (2003). What is clinical empathy? Journal of General Internal Medicine, 18,670-674.
14. Havelka, M. (2016). Zdravstvena psihologija (nastavni testovi). Zdravstveno veleučilište u Zagrebu.
15. HEQI Institut (2025). Iskustvo pacijenata. Online dostupno na: http://www.heqi.com.hr/Iskustvo-pacijenta (Pristupljeno 22.3.2025)
16. Hojat, M.,Mangione, S.,Nasca, J.,Rattner, S, Erdmann, J.B. (2004). An empirical study of decline in empathy in medical school. Journal of Medical Education, 38,934-941.
17. Klain E, Gregurek R i saradnici. (2007). Grupna Psihoterapija –za medicinske sestre i tehničare. Zagreb: Medicinska naklada; 2007.
18. Krešić, V. (2013). Komunikacija u sestrinstvu- međuljudski odnosi zdravstvenih djelatnika. SG/NJ. 2013;18:41-43.
19. Lučanin, D. & Despot Lučanin, J. (2010). Komunikacijske vještine u zdravstvu. Jastrebarsko: Naklada Slap.
20. Lučanin, D. & Despot Lučanin, J. (2010). Komunikacijske vještine u zdravstvu. Jastrebarsko: Naklada Slap.
21. Marco-Ibáñez, A., Aguilar-Palacio, I., Aibar, C. (2023). Does virtual consultation between primary and specialised care improve healthcare quality? A scoping review of healthcare quality domains assessment. BMJ Open Quality, 12(4), e002388.
22. Marković, M. (2008). Poslovna komunikacija sa poslovnim bontonom, CLIO, Beograd, str. 12.
23. Müller, M., Jürgens, J., Redaèlli, M., Klingberg, K., Hautz, W. E., Stock, S. (2018). Impact of the communication and patient hand-off tool SBAR on patient safety: a systematic review. BMJ Open, 8(8), e022202.
24. Nagpal K, Arora S, Vats A, i sar. (2012). Failures in communication and information transfer across the surgical care pathway: interview study BMJ Qual Saf Published Online First: 07 July 2012. doi: 10.1136/bmjqs-2012-000886
25. Paul, M., Maglaras, L., Ferrag, M. A., Almomani, I. (2023). Digitization of healthcare sector: A study on privacy and security concerns. ICT Express, 9(4), 571-588.
26. Perry, M., O'Hara, K., Sellen, A., Brown, B., Harper, R. (2001). Dealing with mobility: understanding access anytime, anywhere. ACM Transactions on Computer-Human Interaction (TOCHI), 8(4), 323-347
27. Proleksis Enciklopedija (2025). Komunikacija. Online dostupno na: https://proleksis.lzmk.hr/1315/ (Pristupljeno, 22.3.2025)
28. Sheehan, J., Laver, K., Bhopti, A., Rahja, M., Usherwood, T., Clemson, L., Lannin, N. A. (2021). Methods and effectiveness of communication between hospital allied health and primary care practitioners: a systematic narrative review. Journal of Multidisciplinary Healthcare, 493-511.
29. Støme, L. N., Wilhelmsen, C. R., Kværner, K. J. (2021). Enabling guidelines for the adoption of eHealth solutions: scoping review. JMIR Formative Research, 5(4),e21357.
30. Waller, M., & Stotler, C. (2018). Telemedicine: a primer. Current Allergy and Asthma Reports, 18, 1-9.
31. White, C. B., Moyer, C. A., Stern, D. T., Katz, S. J. (2004). A content analysis of e-mail communication between patients and their providers: patients get the message. Journal of the American Medical Informatics Association, 11(4), 260-267.
32. Ye, J., Rust, G., Fry-Johnson, Y., Strothers, H. (2010). E-mail in patient–provider communication: A systematic review. Patient Education and Counseling, 80(2), 266-273.

Mešić Zlatko, MA oec.[1]
Brajić Aldin, Ph.D[2]
Brajić Saliha, Ph.D[3]

Original scientific paper

THE INFLUENCE OF DIGITAL TECHNOLOGY ON THE MARKET PERFORMANCE OF SMEs

Abstract

Modern business environment is undergoing radical changes driven by rapid technological innovation, globalization and intense competition. Digital transformation, which is reflected through the application of technologies such as cloud computing, big data analytics, artificial intelligence and the Internet of Things, does not only change operational processes, but fundamentally transforms the way of market performance, positioning with clients and the achievement of company profitability. The aim of this paper is to empirically examine the influence of digital technology on the market performance of SMEs in Bosnia and Herzegovina. Examination of the attitudes of 61 managers showed that digital technologies significantly determine the market performance of SMEs. In addition to the theoretical-empirical coverage of the presented topics, the paper also contains a conceptual model as an instrument for optimizing digital transformation in order to improve the market performance of SMEs.

Key words: *Digital Technologies, Market Share, Market Performance, Regression Analysis.*

1 PhD student at the Faculty of Economics, University of Tuzla, canecorsobih@yahoo.com
2 Assistant professor at International university of Travnik, brajicaldin@gmail.com
3 Assistant professor at Faculty of Economics, University of Bihać, saliha.cabro@yahoo.com

1. Introduction

In today's digital age, the application of modern technologies is a key factor in competitive advantage and efficiency in business. Small and medium-sized enterprises (SMEs), regardless of the activity they perform, are known to play a very important role in the economy of Bosnia and Herzegovina. They make up 99.15% of all economic entities, which is 31,616 small and 1,389 medium-sized enterprises (B&H Agency for Statistics, 2025).

Numerous studies in developed markets show that digital technologies stimulate revenue growth, reduce operating costs and improve the profitability of SMEs (Spremić, 2017; World Economic Forum, 2023; Kidschun et al., 2024). The digital economy has mostly reduced market frictions but also posed new challenges for efficient functioning of markets, especially in the domain of balance between firms' data needs and consumer privacy (Chen, 2020). However, there is a lack of empirical data in Bosnia and Herzegovina that would show to what extent digital technologies concretely contribute to the market results of SMEs, as well as what challenges these companies face in the digitalization process.

Demir (2023) observes the routine use of basic information and communication technology (ICT) tools in the Federation of Bosnia and Herzegovina, while the integration of e-services is delayed. Rondić (2025) confirms the improvement of internal processes, but warns of a lack of digital skills and insufficient investment in enterprise resource planning (ERP) systems. A survey by the Zenica Development Agency (ZEDA, 2019) shows that only 20% of SMEs use ICT for process management, and less than 15% have a formal digital strategy.

The aim of this paper is to investigate the impact of the application of digital technologies on the market performance of SMEs in Bosnia and Herzegovina and to identify the key obstacles to digital transformation. The results are expected to contribute to theoretical discussions on digital transformation in developing economies and provide practical guidance to policy makers and SME managers.

2. Literature Review

Digital technology represents a set of discrete, adaptable and self-referential material components based on the binary representation of data, which enable the generation, storage and processing of information through computer systems and digital networks. The features that make it extremely influential - binary representation, reliability, processing speed and scalability - have transformed communication, work and everyday life and have become key drivers of innovation and foundations of modern society, ensuring improved productivity and quality of life (Carroll, 2017).

Digital data processing represents the conversion of information into discrete numerical values, which enables reliable, precise and fast data transmission and storage. The main features of digital technology include this very binary nature, the ability to endlessly copy and share content without loss of quality,

and to combine data, image and sound into a common digital environment (Negroponte, 1995). According to Vial (2019), digital technologies include a wide range of tools and solutions: from basic computer equipment and software, via the Internet and e-commerce, to modern technologies such as digital services in the cloud, big data analytics, mobile applications and Industry 4.0 concepts (IoT, automation, AI). Digital transformation represents the connection of these technologies in all aspects of business for the fundamental improvement of business performance.

The application of digital technologies today is versatile and ubiquitous: from smartphones, computers and the Internet to complex information systems and artificial intelligence. In everyday use, digital technology includes information and communication technologies (ICT) – such as: digital tools, databases, cloud platforms, social networks, together with digital devices that have become crucial in various sectors (Bawden and Robinson, 2012). As examples, in education multimedia content and digital platforms enable distance learning, in healthcare telemedicine and electronic health records improve patient care, while in industry IoT-enabled smart systems and automation optimize production processes (Wang et al., 2016). Digital technology enables new forms of social communication - from e-mail to social media - enabling faster exchange of information and globally more accessible communication (Castells, 2010).

As stated by Rogulj (2019) digital technology has become a decisive factor in the development of communication and global progress, as it significantly facilitates and improves the transfer of information. The digital revolution, initiated by the development of modern computers in the middle of the 20th century and accelerated by the emergence of mobile technologies and the Internet, transformed all spheres of society, from entertainment and education to business and public services. In today's age, digital technology forms a "networked society" (Castells, 2010), according to which business entities, people and devices are interconnected through a global network of information. This connection causes innovation, efficiency and accessibility of information, but also imposes challenges related to digital literacy, privacy and dependence on technology (Bawden & Robinson, 2012; Terihaj, 2022).

Digital technology has drastically reduced costs in search, transportation, reproduction, and entry offering tremendous new opportunities for higher market efficiency (Chen, 2020). According to Öztürk (2025) the primary forces behind digitalisation are customer needs and the need for quick adoption of novel requirements via organisational resources. His study on turkish SMEs' confirmes that degree of digital maturity is a significant skill for improving organisational performance by allowing organisations to react swiftly to opportunities and risks.

However, it should be noted that many SMEs have still not fully adopted digital transformation in their businesses Yassen et al. (2019) found that lack of human skills, awareness of what digital marketing and technological tools that drives digital marketing were the dominant factors to adopt digital marketing among SMEs companies in Jordan. And yet, SMEs should benefit the most

from the use of digital technologies. Mainly because the nature of digital media such as more accurate metrics, combined with interactivity, have created whole new marketing opportunities (Gillpatrick, 2020).

The authors measure the effects of the application of digital technologies on business and market performance using different approaches. The biggest focus is the application of digital marketing and its effects on customers (Bala & Verma, 2018; Chinakidzwa & Phiri, 2020; Homburg, & Wielgos, 2022). However, it should be pointed out that digital technologies are a broader concept than digital marketing, and that therefore the analysis should be directed towards the companies themselves, that is, their managers.

Regardless of the frequency and intensity of use of digital technologies by SMEs, most authors agree that traditional approaches to business are increasingly losing their importance in achieving market performance. Moeller et al. (2018) state that not technology, but its ability to bring the three drivers to bear: to lower costs, engage customers, and make better use of assets will grant better market performance.

The measurement of market performance is not uniquely defined. The majority of authors start from the assumption that the marketing goals of the business are identified with the financial goals, in terms of achieving sales, profitability, collection (liquidity), and increasing market share. Therefore, the metrics of this work are defined in the domain of dependent variables in this way.

3. Methodology

The subject of research is digital technology and its impact on the market performance of SMEs. Digital technologies and market performance of SMEs will be observed from the perspective of SME managers. Scientifically based methods will provide answers to the following question: Do digital technologies significantly affect market performance of SMEs?

In the paper, the central hypothesis is conceived: "Digital technologies significantly influence market performance of SMEs." From the hypothesis, we can see the independent variable, which is digital technologies, while the dependent variable is defined by the market performance of SMEs.

For the purpose of conducting research, a survey questionnaire was created and delivered to managers of SMEs in Bosnia and Herzegovina. In the questionnaire, a Likert scale with five degrees of agreement was used to examine 7 statements of the independent and 9 statements of the dependent variable. The claims were taken and adapted from a series of scientific research papers of the subject research.

Data collection was carried out on the basis of a controlled random sample, and questionnaires were delivered to potential respondents directly (in person) and via social networks. From the databases of the Agency for Financial, Information and Intermediation Services Sarajevo (AFIP) and the Agency for Intermediation, Information and Financial Services Banja Luka (APIF), legal

entities from the territory of B&H were selected that, according to the Law on Accounting and Auditing of the Federation of Bosnia and Herzegovina and the Law on Accounting and Auditing of the Republic of Srpska, meet the criteria of belonging to small and medium-sized enterprises. In alphabetical order, small and medium-sized enterprises were arranged in the basic group and based on the random principle, using the RNG function, 61 managers were selected in a controlled random sample. The survey was conducted in the period from February 19 to March 20, 2025.

Within the framework of the elaboration of certain theoretical and methodological origins of the observed problem, as well as certain applied considerations, the work used: hypothetical-deductive method, method of induction and deduction, method of analysis and synthesis, statistical methods (descriptive statistical analysis (calculation of parameters of descriptive statistical analysis), and simple regression analysis for the purposes of testing the hypothesis. Data processing and analysis was done in the statistical package IBM SPSS 26.0.

4. Research results

After the research sample was formed, a descriptive analysis of the questions from the first part of the questionnaire was conducted, which included the sociodemographic characteristics of managers. The gender structure includes 47 male and 14 female respondents, while the age structure is as follows: 20-30 years old 9 respondents, 30-40 years old 22 respondents, 40-50 years old 25 respondents, and 50-60 years old. The completed level of formal education is as follows: 27 respondents completed high school, 22 respondents completed college, 7 completed master's studies, 4 completed university, while 1 respondent completed a doctoral study. The length of service of managers is as follows: up to 10 years 23 respondents, from 10 to 20 years 26 respondents, from 20 to 30 years 10 respondents and over 30 years 2 respondents.

The following table 1 shows the construct of "digital technology" and "market performance" with all indicators in the research.

After the descriptive analysis, the reliability of the measurement scales was tested, for which Cronbach's alpha model was used. It is a measure of consistency or internal agreement (Fazlović, 2006). The literature recommends that its value be greater than 0.7. However, the values of this coefficient are very sensitive to the number of items on the scale. According to Kline (1998), if the reliability coefficient (including the Cronbach alpha coefficient) takes a value of around 0.9, the reliability can be considered excellent, if it takes a value of around 0.8, the reliability can be considered very good, while at a value of around 0.7. Yet it is not a rare case that short scales (up to 10 statements) achieve lower values of the mentioned coefficient. The results of the reliability analysis of the scales for digital technologies and SME market performance are presented below.

Table 1. Descriptive statistics

L.V.	Indicators	Arithmetic mean	Median	Mode	Standard deviation
Digital technologies	Your company has adopted digital technology.	3.61	4.00	5	1.345
	Digital technologies have improved the efficiency of your company.	3.75	4.00	5	1.374
	Digital technologies have improved communication within your company.	3.82	4.00	5	1.385
	Digital technologies have enhanced your ability to provide better customer service.	3.85	5.00	5	1.424
	Digital technologies have enhanced your ability to compete in the marketplace.	3.79	4.00	5	1.485
	Digital technologies have improved your ability to collaborate with partners and suppliers.	3.93	4.00	5	1.485
	Digital technologies have improved your ability to attract and retain talent.	3.61	4.00	5	1.417
Market performance	After the introduction of digital transformation, there was a significant improvement in sales and profitability.	3.61	4.00	4	1.269
	After the introduction of digital transformation, there was a significant improvement in liquidity.	3.44	4.00	4	1.360
	After the introduction of digital transformation, there was a significant increase in market share.	3.44	4.00	4	1.360
	After the introduction of digital transformation, there was a significant increase in sales revenue in the main markets.	3.56	4.00	4	1.360
	After the introduction of digital transformation, there was a significant reduction in costs (cost efficiency).	3.33	3.00	3	1.248
	After the introduction of digital transformation, profits were made.	3.52	4.00	4	1.324
	After the introduction of digital transformation, the planned profit was realized.	3.51	4.00	4	1.273
	After the introduction of digital transformation, the planned sales were achieved.	3.61	4.00	4	1.320
	After the introduction of digital transformation, the planned market share was achieved.	3.59	4.00	4	1.257

Source: Authors

Table 2. Reliability analysis of measurement scales

Scales	Cronbach's coefficient alpha	Standardized Cronbach's coefficient alpha	Total number of statements
Digital technologies	0.979	0.979	7
Market performance	0.983	0.983	9

Source: Authors

Based on the results presented in the previous table, and the reference values listed in the literature, it can be concluded that the reliability analysis of the measurement scales for the latent variables: digital technologies and market performance ranges from 0.979 to 0.983, which indicates excellent reliability and internal consistency for this sample. This is also supported by the value of the "Standardized Cronbach's alpha coefficient", which also ranges from 0.979 to 0.983, which further confirms the reliability of the scales.

For the purposes of researching potential causality, and not just the association between phenomena, i.e. variables, it is necessary to apply regression analysis (Soldić-Aleksić & Chroneos Krasavac, 2009). The following table shows the parameters of the simple regression analysis model, where it can be seen that the linear correlation coefficient is 0.781, which points to the conclusion that there is a moderate positive linear relationship between the observed variables.

Table 3. Simple regression analysis model for the dependent variable of market performance[b]

Linear correlation coefficient	Coefficient of determination	Corrected coefficient of determination	Standard error of estimate	Sig. F change
0.781[a]	0.610	0.603	6.96291	0.000

a. Independent variable: digital technologies
b. Dependent variable: market performance

Source: Authors

Based on the coefficient of determination, it is concluded that 61.0% of the variability of the dependent variable – market performance is explained by the selected independent variable - digital technology. The value of the corrected coefficient of determination is very close to the value of the ordinary coefficient of determination. Also, the inclusion of new independent variables in the model brings a statistically significant amount of information, $p = 0.000 < 0.05$ (column Sig. F changes).

Based on the results of the ANOVA procedure, it is concluded that the null hypothesis that the population determination coefficient is equal to 0 is rejected in favor of the alternative, p = 0.000 < 0.05 (column Sig.); F(1.59) = 92.119. In accordance with the above, the statistical validity of the evaluated model is confirmed.

Table 4. ANOVAa – analysis of variance of simple regression analysis model

Model	Sum of squares	Degrees of freedom	Mean square	F ratio	Empirical significance level
Interpreted by the model	4,466.109	1	4,466.109	91.119	0.000[b]
Not interpreted by the model	2,860.448	59	48,482		
Total	7,326.557	60			

a. Independent variable: digital technologies
b. Dependent variable: market performance

Source: Authors

Based on the results from the following table, it can be concluded that the statement that the estimated regression coefficient is statistically significantly different from zero is accepted, p = 0.000 < 0.05 (column Sig.). When it comes to the evaluation of the constant member, the results confirmed its statistical significance, p = 0.012 < 0.05 (column Sig.).

Table 5. Results of simple regression analysis – evaluation of the independent variable

Model	Unstandardized coefficient		Standardized coefficient	t	Sig.
	B	St. error	Beta		
(Constant)	7.006	2.714		2.582	0.012
Digital Technologies	0.933	0.097	0.781	9.598	0.000

Dependent variable: market performance

Source: Authors

The obtained research results confirm the statistical validity of the evaluated model with the corrected coefficient of determination. In addition, a statisti-

cally significant influence of the digital technology dimension on market performance dimension was determined (B = 0.781, p = 0.000). This confirms the second working hypothesis: "Digital technologies significantly affect market performance of SMEs."

Based on the obtained results, it is possible to write down the following evaluated form of the model:

*Market performance = 7.006 + 0.933 * digital technologies*

5. Conclusion

The results of the presented research indicate that there is still a limited application of digital technology when it comes to SMEs. However, those companies that integrate digital technology really achieve market performance. The greatest effect is noticeable in the achievement of set sales goals, which should be a motivator for managers to turn to new, modern business approaches. According to the presented study, it confirms the theoretical and research frameworks of this topic, especially the research of authors such as Rogulj, Chen and Öztürk.

The practical implications of this research include recommending SMEs to develop formal digital strategies and increase investment in modern technologies. Policy makers should provide subsidies, education and promotion of digital literacy in order to overcome barriers to digitization. The development of dynamic company capabilities, such as adaptability and innovation, will further strengthen the long-term sustainability of digital transformation.

The main limitation of the study is the relatively small sample and the focus on the short-term effects of digitization. Future research should conduct longitudinal analyzes to better understand the long-term results of digitization and develop specific strategies to overcome identified barriers.

In conclusion, this research contributes to theoretical discussions on digital transformation in developing economies and provides practical guidance for SMEs and policy makers. Digital technologies represent a key driver of economic growth and sustainable development, but their implementation requires a strategic approach and coordinated support from all relevant actors.

References

1. Agency for Statistics of Bosnia and Herzegovina (2025). Structural business statistics, 2023. Thematic. No.14. Sarajevo. Available at: https://bhas.gov.ba/data/Publikacije/Bilteni/2025/SBS_00_2023_TB_1_HR.pdf
2. Bala, M. & Verma, D. (2018). A Critical Review of Digital Marketing. Int. J. Manag. 8, 321–339.
3. Bawden, D. & Robinson, L. (2012). Introduction to Information Science. London, Facet Publishing.
4. Carroll, La Shun L. (2017). A comprehensive definition of technology from an ethological perspective. Social Sciences, 6(4). https://doi.org/10.3390/socsci6040126
5. Castells, M. (2010). The Rise of the Network Society. 2nd ed. Chichester: Wiley-Blackwell.
6. Chen, Y. (2020). Improving market performance in the digital economy. China Economic Review. Vol. 62. https://doi.org/10.1016/j.chieco.2020.101482

7. Chinakidzwa, M. & Phiri, M. (2020). Impact of Digital Marketing Capabilities on Market Performance of Small to Medium Enterprise Agro-Processors in Harare, Zimbabwe. Business: Theory and Practice. 2, 746-757.
8. Demir, A. (2023). Digital transformation in companies in Bosnia and Herzegovina with the application of digital economy and society indicators. Master's thesis. Sarajevo, Faculty of Economics, University of Sarajevo.
9. Fazlović, S. (2006). Statistics: descriptive and inferential analysis. Denfas, Tuzla.ž
10. Gillpatrick, T. (2020). The Digital Transformation of Marketing: Impact on Marketing Practice & Markets. Economics. 7(4), 139-156.
11. Homburg, C. & Wielgos, D.M. (2022). The value relevance of digital marketing capabilities to firm performance. J. of the Acad. Mark. Sci. 50, 666–688. https://doi.org/10.1007/s11747-022-00858-7
12. Kidschun, F., Gandhi, A. & Hecklau, F. (2024). A Literature Review: The impact of digital transformation on financial performance. Proceedings of the 19th European Conference on Innovation and Entrepreneurship. 19(1), 331-338.
13. Kline, R. B. (1998). Principles and practice of structural equation modeling. New York: Guilford.
14. Moeller, L., Nick H. & Martina, S. (2018). The Coming Wave of Digital Disruption. Strategy and Business
15. Negroponte, N. (1995). Being Digital. New York: Alfred A. Knopf.
16. Öztürk, A. (2025). The Impact of Digital Marketing and Information Technology Capabilities on the Marketing Performance of SMEs in Türkiye. Journal of Information Systems Engineering and Management. 10(9s), 82-92.
17. Rogulj, E. (2019). Digital technologies in communication between educators and parents. Graduation thesis. Zagreb, Faculty of Education.
18. Rondić, I. (2025). Digital transformation in manufacturing companies: challenges and opportunities for medium and small enterprises. Master's thesis. University of Sarajevo, Faculty of Economics.
19. Soldić-Aleksić, J. & Chroneos Krasavac, B. (2009). Quantitative techniques in market research: Application of the SPSS computer package. Belgrade: Center for publishing activities of the Faculty of Economics in Belgrade.
20. Spremić, M. (2017). Digital Business Transformation. Faculty of Economics, University of Zagreb.
21. Terihaj, V. (2022). Digital dementia. Graduation thesis. Rijeka, Faculty of Medicine.
22. Vial, G. (2019). Understanding digital transformation: A review and a research agenda. Journal of Strategic Information Systems, 28(2), 118-144. https://doi.org/10.1016/j.jsis.2019.01.003
23. Wang, S., Wan, J., Li, D. & Zhang, C. (2016). Implementing Smart Factory of Industrie 4.0: An Outlook. International Journal of Distributed Sensor Networks, 12(1). https://doi.org/10.1155/2016/3159805
24. World Economic Forum (2023). Digital transformation can unlock SME potential. Geneva, World Economic Forum.
25. Yaseen, H., Al-Adwan, A. S. & Al-Madadha, A. (2019). Digital Marketing Adoption among SMEs in Jordan: A Mixed Method Approach. J. Theor. Appl. Inf. Technol. 97, 1396–1407.
26. Zenica Development Agency - ZEDA (2019). Research on the state and level of digitization in small and medium-sized enterprises in Bosnia and Herzegovina. November 2019. Available at: https://zenica.ba/wp-content/uploads/2023/09/Anketa_Istrazivanje_stanja_i_nivoa_digitalizacije_u_MSP_u_BiH_ZEDA_2019.pdf

Dina Čajnić[1]
Irfan Djedović[2]
Dino Arnaut[3]

Original scientific paper

INVESTIGATING THE IMPACT OF GENDER, AGE, AND INCOME ON CONSUMER ATTITUDES TOWARD ONLINE SHOPPING IN POST-PANDEMIC BOSNIA AND HERZEGOVINA

Abstract

The objective of this research study is to examine the influence of demographic factors, such as gender, age, and income, on consumer attitudes toward online purchasing in Bosnia and Herzegovina during and after the COVID-19 pandemic. The study aims to identify attitudinal differences and behavioral changes emerging during and after the pandemic, with a focus on changes in terms of trust, digital adaptation, and priorities for consumption. The quantitative method was used, with data collected through an online survey completed by over 300 participants representing various demographic backgrounds. The analysis employed descriptive and inferential statistics, with SPSS software aiding in data evaluation. The study assumes that gender, age, and income have a significant effect on specifying the online shopping preferences and frequency of consumers in the post-pandemic period. Results indicate that younger customers and those with an income higher than average are likely to maintain and to some degree increase their usage of online shopping platforms. Gender differences were also observed, with women showing greater concern for product quality and safety. Meanwhile, older consumers exhibited more hesitancy due to trust and usability issues. These findings offer practical implications for e-commerce businesses and policymakers seeking to address demographic gaps in digital shopping adoption. Suggested measures include creating more access points and improving the user experience, as well as adjusting marketing towards specified demographic characteristics. Further research should also be encouraged for the long-term behavior in the post-pandemic state.

Key words: *Consumer Behavior, Online Shopping, COVID-19, Digital Trust, Bosnia and Herzegovina.*

1 BA of Economics, Master's Student of Management, International Burch University, Francuske Revolucije bb, Sarajevo, dina.cajnic@stu.ibu.edu.ba
2 Associate Professor , International Burch University, Francuske Revolucije bb, Sarajevo, irfan.djedovic@ibu.edu.ba
3 Associate Professor, University of Zenica, Fakultetska 3, Zenica, arnaut.dino@gmail.com

1. Introduction

The COVID-19 pandemic has been the primary phenomenon affecting economies, businesses, and consumer behavior since it emerged in 2020. It has led every government to implement very stringent measures by enforcing lockdowns, social distancing, and restrictions on travel to curtail the virus spread and indeed transform what one is used to in their day-to-day life and buying behavioral shifts. Consumers have shifted significantly to online shopping as offline retail stores have closed or operated less, while there has been a greater acceleration of digital adoption across various sectors.

The pandemic has caused significant changes in the way consumers concern themselves with spending priorities, the brands with which people engage, as well as the frequency of purchasing online. Some consumers shift towards essential goods and stockpiling. Some consumers have shifted towards essential goods and stockpiling, while others have explored new ways of digital shopping, such as contactless payments, home delivery services, and subscribing to purchases. Various studies have shown that the pandemic has had an impact on consumer habits, analyzing the changes in purchasing behavior and attitude toward technology adoption, with long-term implications for businesses. This line of research, however, is limited when it comes to studying the specific impacts of online shopping patterns in Bosnia and Herzegovina.

This research specifically focuses on how gender, age, and income have shaped attitudes toward online shopping in the aftermath of COVID-19 in Bosnia and Herzegovina. The study aims to pursue the following main objective: To determine the impact of COVID-19 in changing consumer behavior towards e-commerce in Bosnia. Therefore, it focuses on key determinants of purchase decisions such as digitalization, consumer confidence, and the new trends in online shopping after the pandemic. Additionally, the role of socio-demographic factors, particularly gender, age, and income, is emphasized to understand how these variables influenced changes in behavior. Moreover, the research also tries to explore whether these changes are transient or reflective of a new and enduring metamorphosis in consumer behavior.

To answer these questions, data is collected through an online survey with a varied sample of consumers who used e-commerce during the pandemic. Differences in frequency, habits of consumption, and methods of payment and delivery are analyzed in comparison to pre-, during-, and post-pandemic periods. The analysis particularly highlights how consumer behavior patterns differ across genders, age groups, and income levels, providing insights into which segments were most impacted and how they adapted. Possible influences of demographic factors such as age, income, and education are further tested on these behavioral shifts.

The outline of this article includes the following: First, a literature review provides an overview of relevant studies on consumer behavior and e-commerce growth during crises. Next is a section on methodology that describes the data collection process and the use of ANOVA analysis as the primary statistical tool

to examine differences in online shopping attitudes across gender, age, and income groups. The results part presents the major findings derived from the ANOVA test, followed by an analysis of their implications for businesses and policymakers. The paper concludes with reflections on the future of e-commerce in Bosnia and Herzegovina, along with recommendations for further research.

2. Literature Review

In this section, previous studies relevant to this research are presented and discussed. The literature review aims to provide theoretical and empirical foundations for understanding how the COVID-19 pandemic influenced consumer behavior, with a specific focus on e-commerce. The selected studies offer insights into the key variables used in this research, including the adoption of digital technology, mobility restrictions, consumer confidence, trust in e-commerce, pent-up demand for non-essential goods, and changes in consumer values. These themes are explored through both global and local perspectives, particularly with reference to Bosnia and Herzegovina.

2.1. Adoption of Digital Technology and Mobility Restrictions

The COVID-19 pandemic significantly accelerated the adoption of digital technology and mobility restrictions forced consumers to shift toward e-commerce. Bhatti et al. (2020) conducted a study that encompassed the entire globe and investigated the potential impacts of lockdowns on shopping behavior, revealing that 52 percent of respondents avoided physical stores for fear of infection, while 36 percent mentioned they would continue to do so until vaccines became readily available. From this study, e-commerce growth formed evident differences for countries with developing markets, such as Pakistan, where online shopping rise from 3% to 10% of overall retail activity. Additionally, it was observed that essential goods are mostly sold in e-commerce, whereas luxury and non-essential commodities had recovery periods much slower. Total adaptation within such a short time frame dictated collaborative efforts in enhancing digital infrastructure and optimizing logistics to meet ever-increasing demand, thus making necessary the fast transformation process into e-commerce activities.

According to Tiwari (2020), consumers' attitudes towards e-commerce are viewed by analyzing online purchasing behavior in the context of various Indian consumers; therefore, there is an indication that psychological dimensions, such as fear of infection, accelerated their transition into digital shopping. It confirmed that mobility restrictions have become a crucial factor for changing consumer behavior towards the online trend, similar to those in Bosnia and Herzegovina, where online shopping was the only resort towards shopping, given that all malls and markets were closed.

Additionally, UNICEF (2022) reported on the economic impact of COVID-19 on families in Bosnia and Herzegovina, noting that nearly one in five households reduced food consumption due to financial constraints. This economic pres-

sure, combined with mobility restrictions, encouraged online shopping as a cost-effective alternative. The study highlighted that rural households faced the sharpest economic challenges, further reinforcing e-commerce as a necessary adaptation during the crisis.

Collectively, these studies indicate how mobility restrictions and the adoption of digital technologies have been prevailing factors propelling e-commerce growth even in developing economies. They provide critical insights for businesses in Bosnia and Herzegovina, which must invest continuously in digital infrastructure to sustain consumer behavior trends post-pandemic.

Furthermore, recent research highlights that the effect of these digital transitions varied across gender, age, and income levels. Women and younger consumers were more responsive to adopting digital channels during the pandemic, while older consumers often faced greater challenges due to limited digital literacy. Moreover, higher-income groups were more likely to shift to online platforms quickly, benefiting from greater access to technology and digital services. These sociodemographic insights are vital for understanding the full spectrum of e-commerce adaptation and should inform future digital inclusion strategies.

2.2. Pent-Up Demand for Non-Essential Goods

Consumer patterns were badly dented by the COVID-19 pandemic, which caused pent-up demand for relative luxuries as restrictions hindered consumers from exercising their purchasing options. In their study, Yang et al. (2023) examined the high-end market in the post-pandemic setting and how promotional campaigns and value-for-money discounts impacted purchasing decisions. Their findings, emanating from a global study, indicate that consumers were seeking indulgence despite financial uncertainties, and that promotional activities played a vital role in stimulating demand. The study thus finds that luxury brands used discounts to divert suppressed consumer spending.

In the same vein, Srivastava and Kumari (2021) analyzed pent-up demand for discretionary goods during the early part of the pandemic. The research tracked global disruptions in the supply chain and stockpiling behavior, wherein consumers were said to worry about shortages and would buy multiple items of non-essentials even when supply was uncertain. Additionally, this phenomenon posed challenges for e-commerce platforms in inventory management. The behavioral research indicates that the psychological uncertainty of the pandemic had less influence on purchasing decisions when they were beyond necessity.

Both these studies provide insight into shifts in consumer behavior with Yang et al. (2023) examining the adaptations within the luxury market, while Srivastava and Kumari highlight changes in general consumer expenditure patterns. Their findings have relevance for the case of Bosnia and Herzegovina, where economic uncertainty created an environment where the consumer was drawn into juxtaposing affordability and aspirational purchases. Findings from this re-

search suggest that companies in Bosnia and Herzegovina can be proactive in ensuring positive accrual by adopting promotional plans and sustainable programs to capture pent-up demand. The findings thus lay the groundwork for following consumer patterns post-pandemic and market adaptation in emerging economies.

It is also notable that income levels significantly influenced the intensity of pent-up demand. Higher-income individuals were more likely to exhibit indulgent purchasing once restrictions lifted, while lower-income consumers remained cautious, prioritizing essential spending. This highlights that post-pandemic strategies for product promotion must consider income disparities and tailor offerings accordingly.

2.3. Trust e-Commerce

Trust is an important component of e-commerce, which greatly influences the consumer decision-making process towards online transactions. Trust implies the belief in the reliability, security, and transparency of an online platform. Such trust impacts purchasing behavior; consumers are more likely to continue with a transaction when they have the confidence that the platform is safe and authentic (Pavlou, 2002). During the COVID-19 pandemic, trust became a more prominent factor since consumers opted for online shopping to avoid crowds and ensure safety. Pestek and Hadžijamaković (2023) demonstrated that social media plays a significant role in earning this trust, for instance, on platforms like Facebook and Instagram, where businesses engage with consumers in transparent ways through real-time feedback and reviews.

Furthermore, the delivery and payment systems offered by these e-commerce sites are crucial in earning consumer trust. Research by Sharma and Rehman (2012) advocates that the communication of delivery timelines, product authenticity, and secure means of payment mitigate perceived risks. Further reinforcing this notion, Jarvenpaa et al. (2000) emphasize the credibility of the brand as a method to build trust, especially during uncertain times like the pandemic, where consumers often rely on well-known brands for online purchases.

Additionally, Uddin (2020) states that trust barriers have been a serious challenge to adopting e-commerce, especially in transitional markets like Bosnia and Herzegovina, where concerns about fraud and data security are at their highest. If these barriers are removed, businesses will be in a position to instill confidence among consumers, thereby furthering the growth of e-commerce.

Recent findings also suggest that demographic factors influence perceptions of trust in e-commerce. For instance, older consumers often expressed greater concern about online fraud and preferred cash-on-delivery options, while younger consumers were more open to using digital wallets and sharing personal data for convenience. Addressing these trust gaps across age groups is essential to creating a universally accessible e-commerce environment.

2.4. Consumer Confidence

This research primarily analyzes changes that took place in consumer behavior amid COVID-19, focusing on e-commerce growth from the experience of changes in consumer values and priority shifts. As noted by Ben Hassen et al. (2021), the pandemic changed priorities among consumers; there exist priorities such as health, sustainability, and social connectivity that became essential compared to price and convenience. They argue that such changes are global but may find it hard to take root permanently in some economies that have major financial constraints. The paper also advocates for appropriate government policy support for local production so that the potential benefits of such preferences can be optimized over time without developing locavore memories.

Hesham et al. (2021) examined the effects of pandemic incidence on consumer values and buying behaviors by classifying consumers as optimistic or not. They found that consumer values were altered by the pandemic. Most pessimistic consumers have begun stockpiling, with the primary focus being on health and safety; on the other hand, optimistic shoppers give priority to comfort and psychological wellness. This revelation highlights the strong influence of digital technology on consumption change, whereby a significant number of shoppers are currently choosing to purchase over the Internet because it is safer compared to the market.

Di Crosta et al. (2021) further examined the psychological aspects of consumer behavior, showing how fear, uncertainty, and risk perception predicted purchasing decisions. Most consumers became value consumers with strong preferences for healthy and safe products. Furthermore, the study found a considerable difference in the reactions of consumers during the crisis based on age and gender.

All these studies emphasize the long-term effects of the pandemic on consumer behavior, with special regard to e-commerce and the need for businesses to plan future strategies affected by changing consumer values, in particular for markets such as Bosnia and Herzegovina.

In addition, research indicates that consumer confidence during the pandemic was closely linked to government response and media communication. Countries with transparent, consistent messaging and clear public health strategies were more likely to maintain moderate levels of consumer confidence. In contrast, misinformation and lack of coordination heightened anxiety and economic pessimism. This suggests that clear communication from both governments and businesses can play a critical role in stabilizing consumer expectations and encouraging economic activity, especially during crises.

2.5. Changes in Consumer Values

Dangelico et al. (2022), focusing on consumer value change as a result of COVID-19, stressed the need for sustainability and support for local economies. Their study found that older consumers (55-65) were more inclined to support local businesses, while women exhibited stronger moral duty concerning their

purchases. The pandemic brought awareness of sustainability to the forefront of consumer demand for environmentally friendly products and transparent supply chain operations.

Sun et al. (2021) conducted studies in China in line with similar findings, where consumer awareness of sustainability increased tremendously during the pandemic. Evidence from their findings suggests that ethical considerations became more important than cost, representing a watershed moment in purchasing behavior. Some consumers were concerned with eco-friendly and socially responsible goods, thus reinforcing the pandemic global pull on consumption.

Ben Hassen et al. (2021) conducted one of the largest surveys devoted to examining changes to food consumption during the pandemic. They found that of the respondents, 25.66% had increased consumption of healthy foods while 15.8% tended to favor food produced locally; about food shopping, these habits could be interpreted as more in favor of sustainability as well as being health-conscious. In other words, dining has entered a new period of focus on family values and community with such heavy emphasis on consumer values.

These studies suggest that the consumer behavior changes caused by COVID-19 did promote environmental awareness, ethical purchasing, and support for local economies; nevertheless, further research is needed to assess if these changes will be sustainable in the long run.

Moreover, recent insights suggest that this shift in consumer values has influenced brand loyalty and purchase decision-making across various sectors. Consumers are increasingly aligning their preferences with companies that demonstrate environmental and social responsibility. Brands that transparently communicate their sustainability initiatives, such as carbon footprint reduction, eco-packaging, or fair labor practices, are seeing increased consumer engagement. This trend signifies not just a temporary change, but a potential long-term transformation in the consumer-brand relationship driven by deeper personal and societal values.

2.6. Consumer Behavior

Shaw et al. (2022) studied the effects of different models, including fulfillment, security, efficiency, privacy, and perceived usefulness, which influence consumer behavior in terms of online purchases. These issues become more significant, particularly in the case of Bosnia and Herzegovina, for the conditioned behaviors that consumers developed during the pandemic, where logistical issues were prevalent in fulfilling online orders as well. Security concerns have caused adoption difficulties, especially for older generations. Additionally, concerns regarding the efficiency and usability of websites, as well as privacy issues, gained more focus.

Dangelico et al. (2022) similarly noted that the pandemic had fast-tracked digitalization, thrusting e-commerce to the forefront due to lockdown and physical distancing measures. This trend was observed, among others, by Degli Esposti et al. (2021) and Vittuari et al. (2021), who showed that more reliance on e-com-

merce was necessitated by health concerns and mobility restrictions, driving the consumer to the online sphere. Moreover, a study by Hesham et al. (2021) on this shift within Bosnia and Herzegovina revealed that due to the pandemic, visits to grocery stores were reduced significantly, with consumers instead seeking options in online shopping, particularly focusing on local products to ensure safety. There were also dramatizing psychological effects, such as those hit by health consciousness and the demand for more customized online shopping. All this implied permanent behavior changes that would indicate the long-term consequences of the pandemic on e-commerce as well as consumer behavior within Bosnia and Herzegovina.

Additionally, psychological resilience and adaptive behavior have emerged as key determinants of consumer responses to crisis-induced disruptions. Research shows that consumers who demonstrated higher levels of adaptability were more likely to experiment with new shopping methods, embrace digital platforms, and maintain satisfaction despite uncertainties. This behavior not only altered individual habits but also influenced the broader digital retail landscape, encouraging innovation and personalization in service delivery. Understanding these behavioral shifts is crucial for developing future-ready retail strategies.

3. Research Model, Hypotheses and Research Questions

This section outlines the key research questions that aim to explore how demographic variables, specifically age, income, and gender, shaped consumer behavior related to online shopping during and after the COVID-19 pandemic in Bosnia and Herzegovina.

RQ1: How did the COVID-19 pandemic impact online consumer behavior across different age groups in Bosnia and Herzegovina?

RQ2: How do income levels influence changes in online shopping behavior during and after the COVID-19 pandemic?

RQ3: Are there gender-based differences in online shopping behavior that emerged or intensified during the COVID-19 pandemic?

These questions reflect the study's goal of uncovering how individual differences affected the adoption, frequency, and perception of online shopping, providing a demographic lens on consumer responses to pandemic-driven changes.

4. Methodology

Using an online questionnaire, this particular study analyzed the effects of COVID-19 on consumer behavior regarding online shopping in the pre-COVID-19, during-COVID-19, and post-COVID-19 phases. The survey, which was conducted between December and February, included topics such as demographics, online shopping frequency, methods of payment, and factors influencing purchasing decisions, such as convenience, price sensitivity, and acceptance of digital technology. The online survey was distributed over Google Forms and different social media platforms, as well as through emails and personal contacts. A total of 347 completed responses were received; thus, providing a re-

liable basis for the analysis. Data analysis was accordingly performed using SPSS, using descriptive statistics, ANOVA, regression analysis, and reliability and validity checks. Ethical measures ensured confidentiality for all participants and their voluntary nature.

5. Data and Findings

5.1. Demographics of Sample

The sample in this study was predominantly female, which may reflect a greater interest in online shopping or survey participation among women. The largest age group comprised respondents aged 18-24 years, with women making up a larger fraction.

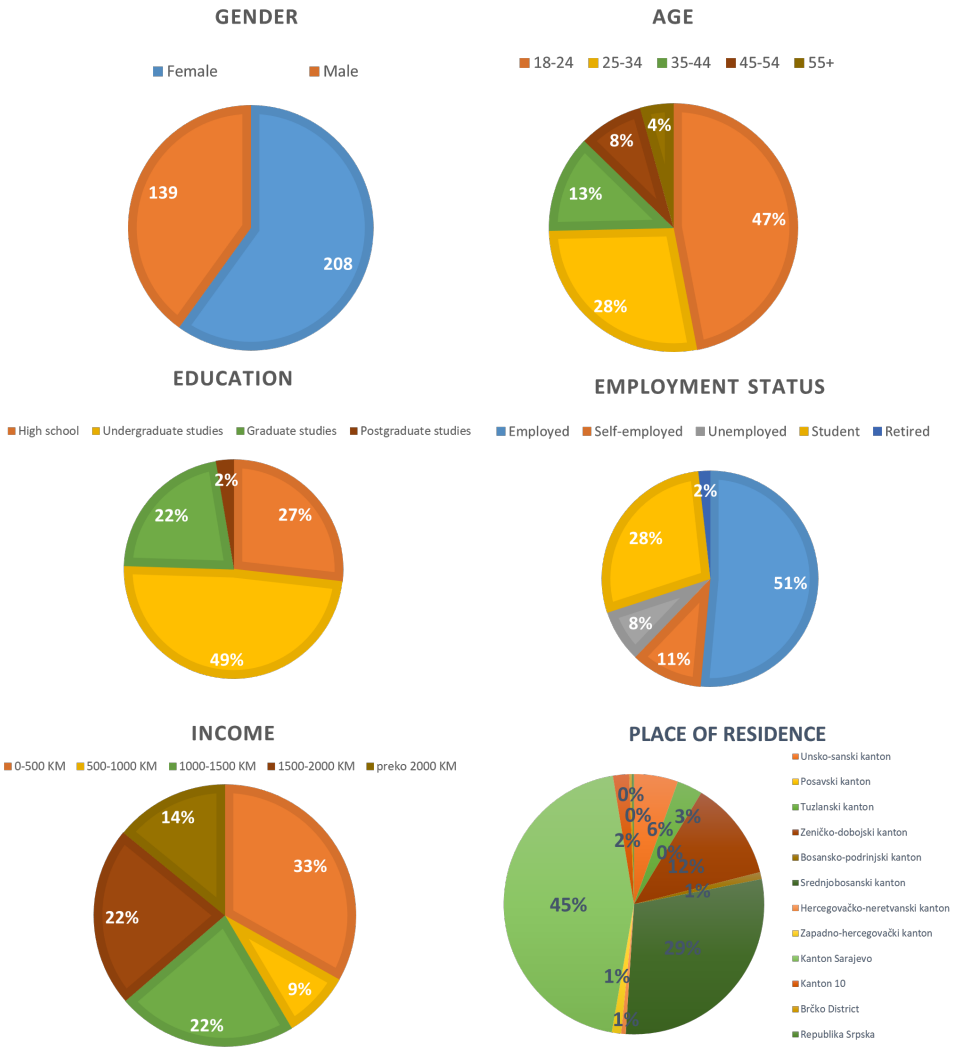


Figure 1. Demographics of Sample

Younger generations, especially women, tend to be more online-oriented in their shopping habits than older generations. Regarding employment, most respondents would classify as employed: women tended to work in formal employment, while men tended towards self-employment. For income level, women were more represented in lower income categories, while men were much more represented in higher income brackets, suggesting the existence of a gender pay gap. The majority of respondents were from Sarajevo Canton, where urban women shopped more than rural women. They considered having access to more varieties and convenience as the main things online shoppers wanted; women were about variety considerations, while men were about price and efficiency. Most respondents were occasional online shoppers rather than habitual or daily shoppers, where women naturally shopped more.

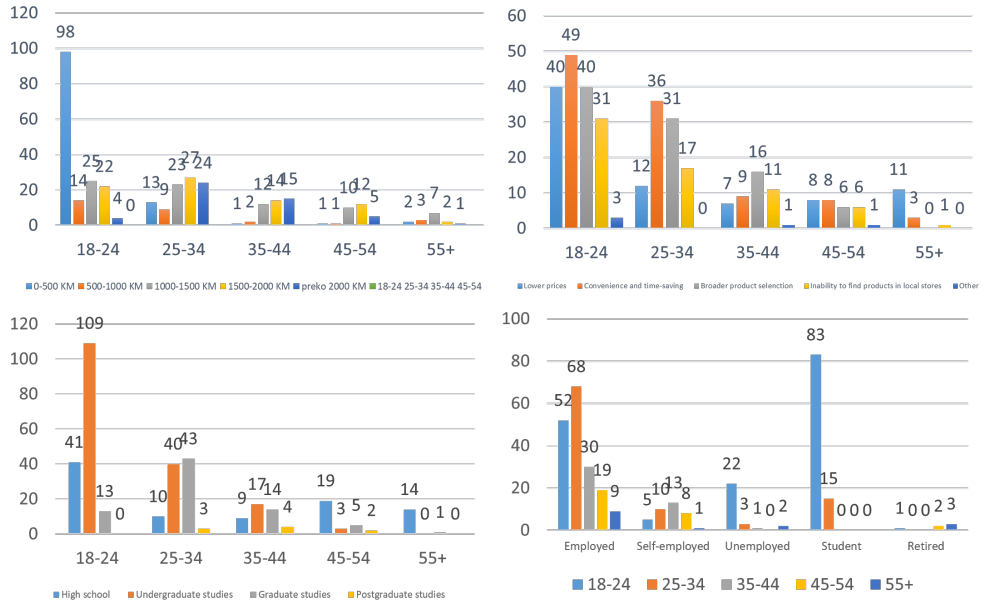
5.2. Data analysis

5.2.1. Age

The pandemic experience of COVID-19 has profoundly redesigned online shopping patterns in Bosnia and Herzegovina, particularly among younger people, but the older generations remain guarded in their online shopping habits. This age group was still dominated by occasional shopping (88 respondents), but a significant number shopped often (55) or even daily (13). Their limited daily expenditures were incurred through an inheritance from their parents or a student budget, which drove them online when physical stores were closed. The group aged 25 to 34 made an even further leap, with only one never shopped online, while 47 did so occasionally, 39 often, and 9 every day. This age group had just shifted from education to a stable income, with 27 earning between 1,500 to 2,000 KM and 24 earning more than 2,000 KM per month, allowing for more frequent online engagements. The 35-44 and 45-54 groups also showed increases in e-shopping, with occasional use remaining dominant (20 in each group), while frequent and daily use also occurred. Those over the age of 55 shopped online with almost total occasionaly (14 respondents) and not every day, reflecting generational differences in technology adoption.

However, because 59.9% of our sample are women, this gender imbalance may reflect a sampling bias - women might have been more motivated to respond to an online survey on shopping, thus, the age patterns observed could be amplified by the over-representation of digitally-engaged female youth.

This is further reflected in the income trends, which entrench the age patterns by the fact that almost all 18 to 24-year-olds (98) earned under 500 KM (Table 2.a). This meant less shopping beyond essentials, hence discounts and other promotions became critical reasons for shopping. The increased earnings of the 25-34-year-old cohort addressed the ability to spend more online, as this segment of earners decreased dramatically among lower incomes, while mid to high earners flourished and were able to take advantage of home delivery, courtesy of lockdowns. At 35-44 years, most respondents reported earnings above 2,000 KM, meaning they could afford non-essential purchases online. However, retirees (aged 55+) largely had fixed moderate incomes, thus reducing engagement. This tells a story of economic resources opening the digital



a) Spending by Age Group; b) Motivations for Online Shopping;
c) Educational Background of Respondents; d) Employment Status by Age Group;

Figure 2. Online Shopping Patterns and Demographics by Age Group During COVID-19

doors to everyone experiencing the pandemic, while also determining how often one purchases and how much time one spends online. The motivations differ according to age, but the result always boils down to convenience and assortment. To younger shoppers, it meant time savings and a much wider selection of both access-denied responses and stretched budgets for low-price alternatives. Moreover, we only measure frequency, not actual spend, so we cannot determine whether occasional shoppers made high-value purchases or just small, infrequent transactions, which limits how far we can generalize these behavioral shifts.

This was a catalyst for COVID-19: the young consumers perceived e-learning to amplify entertainment, social connection, and need. Changes in educational and employment opportunities further impacted these behaviors. Students and entry-level professionals became more digitally fluent through remote learning and telework, resulting in their ease with online buying platforms. Those in mid-career stages were inclined to take advantage of stable incomes and flexible schedules to convert to e-tailing for everything from groceries to electronics (Table 2.a). Additionally, because our survey was distributed online and promoted via social media channels, we may have undersampled less tech-savvy older adults and those without reliable internet access, introducing a sample bias towards more digitally connected respondents.

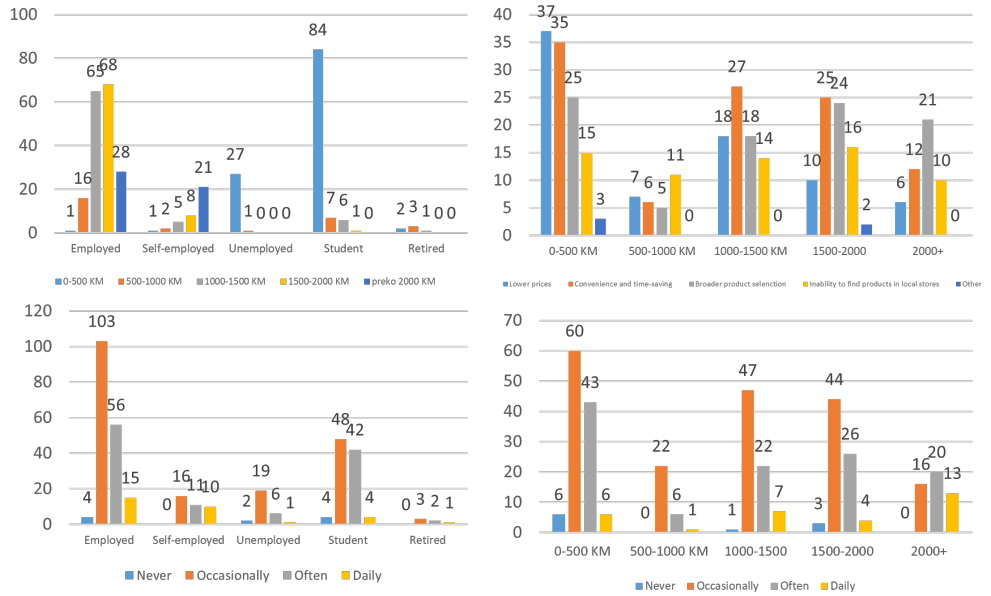
Geography aligns itself with age, especially among the urban youth in the Sarajevo Canton. They are beneficiaries of robust internet infrastructure and deliv-

ery networks, while their rural and older compatriots are still more widely dispersed across regions due to persistent digital divides. All in all, COVID-19 has hastened the advent of online shopping for Bosnian and Herzegovinian consumers, but with a significantly different effect depending on age. For young adults, the imposed restrictions provided the conditions for consumption in a digital format; mid-life earners consolidated their online habits further through a new means of buying; seniors are still dabbling with e-commerce, however cautiously. Businesses and policymakers aiming to promote inclusive digital growth going into the post-pandemic future will need to understand these fine-grained age dynamics (Table 2.e).

The coronavirus contagion outbreak was an important stimulatory factor in the adoption of electronic commerce in Bosnia and Herzegovina; however, the effects were different across age cohorts. Young adults ages 18 to 34 were propelled into the fastest growth of e-commerce because of the combined effect of necessity, the ability to use technologies, and, in the case of the older half of the cohort, the increased financial means to afford it. This occasional utilization changed quickly into a significant increase in almost every day purchases as the lockdowns continued. Mostly, adults became more occasional users in the latter years of use, while their older counterparts became infrequent ones, due to deep-seated preferences, such as limited income, that hindered them from making a complete transition to digital channels. In summary, various patterns have shown that even though the pandemic has opened roads for almost everyone into the e-commerce space, true acceptance of it depends on combinations of digital literacy, a constant stable income, and perceived value. Still, because we did not collect data on actual spending amounts or basket sizes, our conclusions about "acceptance" rely solely on reported shopping frequency rather than economic impact, which may overstate behavioral change. For businesses and policymakers, the straightforward lesson will be about the necessity for targeted support, whether through promoting easy-to-navigate, user-friendly platforms for older adults, promotion incentives for youth with tight budgets, or improving infrastructure in less urbanized areas, as this will be the key to sustaining and broadening the e-commerce gains made during the pandemic.

5.2.2. Income

The economic upheaval of the COVID-19 pandemic reshaped online shopping habits in Bosnia and Herzegovina in ways that closely tracked consumers' monthly income levels. Among those earning under 500 KM per month, primarily students and entry-level workers, online shopping became a strategic tool for stretching limited budgets. Although occasional shopping dominated (60 respondents), a surprisingly high number (43) reported shopping often, and even daily shopping appeared (6 respondents) (Table 3.a). This pattern suggests that low-income consumers turned to e-commerce not only out of necessity during lockdowns, but also as a way to hunt for discounts and compare prices across multiple vendors. For this group, "lower prices" was the most cited motivation (37), yet "convenience and time-saving" (35) and "broader product selection" (25) also featured prominently, indicating that pandemic-era supply



a) Income Level Distribution by Employment Status; b) Motivations for Online Shopping by Income Level; c) Frequency of Online Shopping by Employment Status; d) Frequency of Online Shopping by Income Level

Figure 3. Online Shopping Patterns and Demographics by Income Level and Employment Status During COVID-19

disruptions and local store closures pushed budget-conscious shoppers online even when price remained their primary concern. (Table 3.b)

Consumers in the 500–1,000 KM bracket exhibited a similar but slightly tempered behavior: 22 shopped occasionally, 6 shopped often, and only 1 shopped daily. Their motivations echoed those of the lowest bracket, with "lower prices" (7) again leading, followed by "convenience and time-saving" (6) and "broader product selection" (5). (Table 3.b)

A noticeable shift occurs among mid-range earners (1,000–1,500 KM and 1,500–2,000 KM). Here, occasional shopping still prevailed (47 and 44 respondents respectively), but the number of "often" and "daily" shoppers rose appreciably (22 and 26 often; 7 and 4 daily). For these segments, while "lower prices" remained important (18 and 10), "convenience and time-saving" (27 and 25) and "broader product selection" (18 and 24) emerged almost equally as critical motivators. The financial stability of mid-income groups appears to have allowed them to leverage e-commerce for its practical benefits—avoiding crowded stores, gaining access to a wider assortment, and adapting to work-from-home lifestyles, rather than solely for cost savings. (Table 3.d)

At the highest income level (over 2,000 KM), a distinct pattern emerged: occasional shopping remained most common (16 respondents), but "often" (20) and "daily" (13) shopping also rose, indicating that high earners fully integrated online purchasing into their routines. In this bracket, "lower prices" dropped to

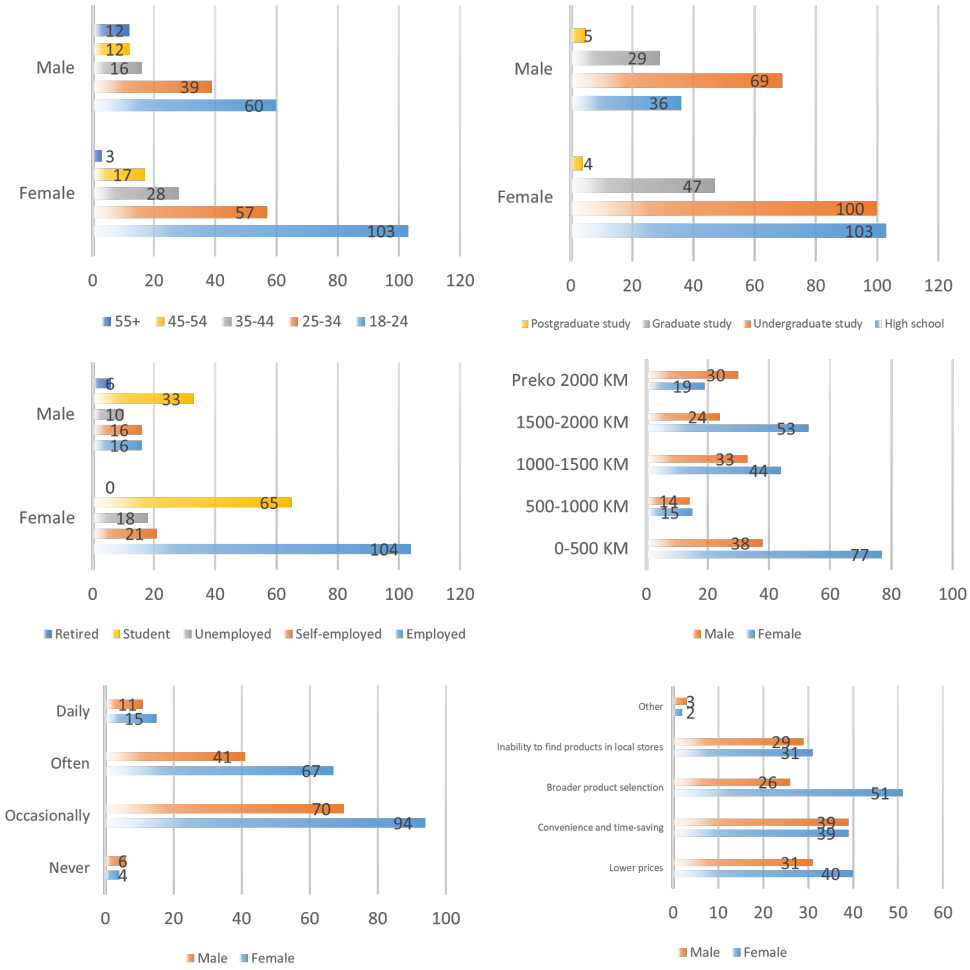
only 6 mentions, overtaken by "broader product selection" (21) and "convenience and time-saving" (12). High-income consumers, less constrained by cost considerations, clearly valued e-commerce for its ability to deliver specialized or premium products and to fit seamlessly into busy lifestyles intensified by pandemic-era work demands. (Table 3.d)

The COVID-19 pandemic magnified existing income-based divides in online shopping behavior. Low-income consumers gravitated toward e-commerce primarily as a cost-saving measure, often leveraging digital platforms to find deals and promotions. Middle-income groups balanced price sensitivity with a growing appreciation for convenience and product variety, while high-income shoppers embraced online channels as an efficient way to access premium goods and services without regard to price. These divergent patterns underscore the need for e-retailers and policymakers to tailor strategies by income segment- offering targeted discounts and user-friendly comparison tools for budget-constrained shoppers, while emphasizing speed, variety and premium experiences for wealthier customers- in order to sustain and deepen the digital marketplace gains achieved during the pandemic. Future research should also explore how these behavioral shifts evolve in the post-pandemic period, particularly in light of inflationary pressures and technological advancements in the region.

5.2.3. Gender

The survey's gender breakdown, 208 women (59.9%) and 139 men (40.1%), already signals that women were both more willing to participate and perhaps more engaged in online shopping during the COVID-19 era (Table 4.a). When physical stores shut their doors or imposed strict capacity limits, women in our sample leaned into e-commerce more heavily than men, driven by a blend of practical and psychological factors. Whereas men often viewed online channels as a functional alternative, valuing efficiency and low prices, women embraced the convenience, the virtually limitless product assortment, and the sense of control that digital browsing afforded at a time of heightened uncertainty. Even accounting for age and income differences, the gender gap in frequency was clear: women were somewhat more likely than men to report shopping "often" or "daily," while men remained clustered in the "occasional" category. (Table 4.e) This behavioral split aligns with prior research that highlights how women's shopping behavior often includes a greater emotional and exploratory component, while men typically exhibit more utilitarian patterns (e.g., Dittmar et al., 2004).

Several factors lie behind this divergence. First, many women juggle household management, childcare, and, increasingly, remote work, a combination that made in-store shopping more burdensome during lockdowns. Online retail promised time-saving order fulfillment and home delivery, freeing up scarce hours for other responsibilities. Men, by contrast, were more prone to delay non-essential purchases until they could visit physical outlets again or to limit their online interactions to specific needs, electronics, tools, or hobby items, where price and technical specifications dominate. In our data, the classic "window-shopping" impulse found digital expression among women who explored



a) Age Distribution by Gender; b) Educational Background by Gender;
c) Employment Status by Gender; d)Income Level Distribution by Gender;
e) Frequency of Online Shopping by Gender; f) Motivations for Online Shopping by Gender

Figure 4. Online Shopping Patterns and Demographics by Gender During COVID-19

new brands, styles, and categories when stuck at home, even if they did not always convert every browse into a purchase. This highlights not only differences in purchase behavior but also in online browsing intent, an aspect often overlooked in standard consumption analyses.

Motivations further split along gender lines (Table 4.f). Among women, “wider assortment” and "time-saving convenience" were the top reasons to click “buy,” whereas men’s responses were more evenly spread across “low price,” “convenience,” and “selection.” This suggests that women used the pandemic pause to discover products they could not easily find locally, beauty items, fashion, and home decor, while men treated online platforms more transactionally, hunting

deals on items they already knew they wanted. As incomes fluctuated under pandemic pressures, both genders cited price sensitivity, but women more often combined discount-seeking with exploratory shopping, whereas men zeroed in on the cheapest available option for a known need. These findings resonate with gendered risk perception in uncertain times, women may have seen online shopping as a safer, more flexible option, while men evaluated it more from a cost-benefit standpoint.

Employment status and income interacted with gender to amplify these effects (Table 4.c). Employed women, especially those in formal sectors, used stable paychecks to maintain household supplies via online orders, while self-employed men, facing business disruptions, sometimes held back on personal e-purchases. Female students, constrained by lean budgets, nevertheless shopped online more regularly than their male peers, drawn by flash sales and coupon codes. In contrast, male retirees and mid-career professionals tended to revert to in-store habits as soon as restrictions eased, reinforcing a more episodic use of e-commerce. This intersectional insight, combining gender, employment, and income, adds granularity to an otherwise binary view of consumer behavior.

In summary, COVID-19 did not simply boost overall e-commerce; it reshaped gendered patterns of digital consumption. Women turned necessity into opportunity, melding price consciousness with discovery and convenience, whereas men maintained a narrower, need-driven approach. Understanding these distinct trajectories is vital for e-tailers: personalized messaging, interface design, and promotional strategies must reflect that women seek variety and empowerment in online shopping, while men prioritize streamlined, goal-oriented transactions.

The pandemic accentuated pre-existing gender differences in online shopping. Women emerged as the more adventurous, frequent, and diversified e-shoppers, leveraging digital channels to balance time pressures and broaden their purchasing horizons. Men, though active, remained more reserved, treating online retail as a tactical tool for specific needs rather than a primary shopping mode. Tailoring post-COVID e-commerce experiences to these contrasting mindsets will be key to sustaining growth across both segments.

5.3. ANOVA

The analysis utilized ANOVA to examine how demographic variables such as age, gender, and income level influence online shopping behavior during and after COVID-19. Findings revealed that age significantly impacts consumer behavior, where older (55+) individuals were more engaged in online shopping than their younger counterparts. Levene's test ascertained a case for unequal variance ($p=0.011$). However, ANOVA continued to provide a significant difference ($F=14.609$; $p<0.001$). For the outcome of different age groups, post-hoc comparisons (Games-Howell) confirmed older consumers' behavioral differences (55+) from younger groups, while 18-44 age groups were found not different from each other.

This suggests that digital adaptation and possibly health-related caution contributed to stronger online engagement in older age groups, particularly those with more limited mobility during lockdown periods.

Under the analysis of gender through independent samples t-tests, although women had a slightly higher mean score (2.44) compared to men (2.28), it did not record any statistically significant difference ($p = 0.088$). Levene's test indicated ($p = 0.347$) equal variances, and Cohen's d suggested a large effect size (1.10) without statistical significance. This means that gender does not affect online shopping behavior.

The lack of statistical significance here may reflect a relatively uniform shift to online shopping across both genders during the pandemic, driven more by necessity and access than by preference.

Regarding income level, ANOVA revealed only minor differences. The group of respondents earning 500-1000 KM had the highest consumer behavior score (2.83) while the category above 2000 KM had the lowest (2.17). As for the significance level ($p=0.048$), it only existed between the 0-500 KM and 1000-1500 KM groups, with a small effect size (eta-squared=0.044), which means income is somewhat good at specifying the moderate impact.

This small effect may be related to the broad income brackets used, which limit detailed interpretation of purchasing power. Still, the data suggest that moderate-income consumers may be more price-sensitive and therefore more active online shoppers during uncertain economic periods.

Key motivations for online shopping include price advantage, convenience, time savings, and product availability. Lower price ranked highest, while lack of availability in local stores also played a major role.

Notably, respondents who do not shop online (n=5) had the highest mean score (4.72), highlighting a unique behavioral cluster possibly driven by unfamiliarity or mistrust toward digital platforms.

Shopping frequency analysis revealed that most respondents shop online occasionally. ANOVA showed significant behavioral differences between frequency groups, with post-hoc tests confirming variations between "Never," "Occasionally," and "Often" groups.

These results emphasize the relevance of shopping frequency as a predictor of behavioral patterns, with daily users displaying the lowest mean scores (1.71), indicating more habitual, perhaps utility-driven online shopping.

Overall, consumer behavior in online shopping is influenced more by age and shopping frequency than by gender or income level.

The descriptive analysis also revealed regional and educational disparities, although further inferential testing would be required to confirm these patterns. In particular, respondents from Kanton Sarajevo and those with undergraduate degrees reported the lowest consumer behavior scores, hinting at more routine or rational online shopping behavior in these groups.

Table 1. ANOVA

Descriptives								
Consumer_Behavior								
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
					Lower Bound	Upper Bound		
Age								
18-24	163	2,2086	1,01771	0,07971	2,0512	2,366	1	5
25-34	96	2,1917	1,00814	0,10289	1,9874	2,3959	1	5
35-44	44	2,4045	0,97646	0,14721	2,1077	2,7014	1	5
45-54	29	2,9931	1,29227	0,23997	2,5016	3,4847	1,2	5
55+	15	4,0533	0,63004	0,16268	3,7044	4,4022	2,6	5
Total	347	2,3741	1,10014	0,05906	2,2579	2,4902	1	5
Gender								
Male	139	2,2763	1,06958	0,09072				
Female	208	2,4394	1,11788	0,07751				
Income								
0-500 KM	115	2,2365	1,08372	0,10106	2,0363	2,4367	1	5
500-1000 KM	29	2,8276	1,20205	0,22322	2,3704	3,2848	1	5
1000-1500 KM	77	2,6753	1,04481	0,11907	2,4382	2,9125	1	5
1500-2000 KM	77	2,2364	1,16109	0,13232	1,9728	2,4999	1	5
preko 2000	49	2,1714	0,91742	0,13106	1,9079	2,4349	1	4,4
Total	347	2,3741	1,10014	0,05906	2,2579	2,4902	1	5
What is your main reason for shopping online?								
Lower prices	78	2,3949	1,18123	0,13375	2,1285	2,6612	1	5
Convenience and time-saving	105	2,2629	1,02781	0,1003	2,064	2,4618	1	5
Broader product selection	93	2,1419	0,90149	0,09348	1,9563	2,3276	1	5
Inability to find products in local stores	66	2,6758	1,15066	0,14164	2,3929	2,9586	1	5
Not buying online	5	4,72	0,43818	0,19596	4,1759	5,2641	4	5
Total	347	2,3741	1,10014	0,05906	2,2579	2,4902	1	5
How often do you use the internet for online shopping?								
Never	10	4,06	1,10373	0,34903	3,2704	4,8496	2,2	5
Occasionally	189	2,5704	1,13941	0,08288	2,4069	2,7339	1	5
Often	117	2,0872	0,8911	0,08238	1,924	2,2503	1	5
Daily	31	1,7161	0,65478	0,1176	1,476	1,9563	1	4
Total	347	2,3741	1,10014	0,05906	2,2579	2,4902	1	5

Place of residence								
Unsko-sanski kanton	19	2,8737	1,05874	0,24289	2,3634	3,384	1	4,4
Tuzlanski kanton	13	2,6923	0,94381	0,26176	2,122	3,2626	1,4	4,4
Zeničko-dobojski kanton	43	2,5302	1,06983	0,16315	2,201	2,8595	1	5
Bosansko-podrinjski kanton	3	2,4	0,87178	0,50332	0,2344	4,5656	1,4	3
Srednjobosanki kanton	101	2,5307	1,18977	0,11839	2,2958	2,7656	1	5
Hercegovačko-neretvanski kanton	2	3,1	1,55563	1,1	-10,8768	17,0768	2	4,2
Zapadno-hercegovački kanton	4	2,15	0,86987	0,43493	0,7658	3,5342	1,4	3
Kanton Sarajevo	155	2,1677	1,04905	0,08426	2,0013	2,3342	1	5
Kanton 10	7	1,6857	0,55205	0,20866	1,1752	2,1963	1,2	2,8
Total	347	2,3741	1,10014	0,05906	2,2579	2,4902	1	5
Educationl level								
High school	93	2,8022	1,1354	0,11774	2,5683	3,036	1	5
Undergraduate studies	169	2,1278	1,02295	0,07869	1,9725	2,2832	1	5
Graduate studies	76	2,3421	1,00814	0,11564	2,1117	2,5725	1	5
Postgraduate studies	9	2,8444	1,53225	0,51075	1,6667	4,0222	1	5
Total	347	2,3741	1,10014	0,05906	2,2579	2,4902	1	5
Employment status								
Employed	178	2,4494	1,10562	0,08287	2,2859	2,613	1	5
Self-employed	37	2,0108	0,79992	0,13151	1,7441	2,2775	1,2	4,4
Unemployed	28	2,6286	1,00916	0,19071	2,2373	3,0199	1	4,2
Student	98	2,2163	1,12723	0,11387	1,9903	2,4423	1	5
Retired	6	3,7667	1,16905	0,47726	2,5398	4,9935	1,8	5
Total	347	2,3741	1,10014	0,05906	2,2579	2,4902	1	5

6. Discussion

Although there were some very interesting findings from the research on consumer behavior during the COVID-19 pandemic, there are also many areas of research and intensive thinking that remain to be explored. For instance, one of the key insights is that demographic factors such as age, income, and gender significantly affect consumers' patterns of online shopping. While these factors do influence purchasing behavior, the findings must still be scrutinized within the context of more extensive socio-economic trends as well as technological advances.

Age was found to be one of the strongest predictors of the intensity with which online shopping occurred. Youths aged 18-34 years turned out to be the most frequent online purchase makers, as studied in previous literature, which posited that the younger cohort tends to adopt new technologies due to their digital literacy and flexibility. At the same time, this finding does not capture the nuanced realities associated with the generational gap. While younger people are digitally proficient, they also have more chances of being unstable in their finances; this may also affect their buying decisions when using online platforms. In addition, older individuals (55 and above) were hardly online shoppers but contingent in their purchases. The pandemic definitely made things worse for them, but it only enforced their inclination to be digitally adaptive; however, this indicates that the group has continued limited interfacing with all the possible barriers to digital inclusiveness for older demographic groups, which include lower levels of trust towards the web for e-commerce and a seldom use of any online payments.

Income is found as another major factor in predicting consumer behavior, and those belonging to the middle-income bracket (500–1000 KM) made the most purchases online. This finally supports the framework that middle-income consumers fall within a range of purchasing power, and their sensitivity becomes a favorable option for online shopping as a channel. It is generalized that assumptions give the notion that high-income individuals visit brick-and-mortar stores due to their opulence. High-income people could even opt for online purchases for convenience or a different set of categories of products, such as luxury items or specific online-exclusive deals. This nuance indicates that online shopping behavior across income categories does not just appeal or is driven solely by economic necessity, but also has a significant impact on convenience and product availability.

The gender differences that emerged in the present study, although statistically insignificant, needed to be discussed further. There were slight indications that women were more likely to engage in online shopping, consistent with previous findings that suggested women were more likely to use digital platforms for reasons of perceived convenience and time saved. However, samples must be taken as primarily female, since the sampling could have resulted in bias. Also, the difference between the exploratory and transactional woman and man is an oversimplification.

A tendency for women to be interested in a wider range of products is matched by men who generally consider mostly the functions of the product and also its price, which indicates that the differences in the behavior of shoppers online may be based on deeper issues of psychology and social reasons, and not just mere demographic differences.

While more populous cantons, particularly Sarajevo, demonstrate a higher level of online shopping due to improved digital infrastructure and delivery services, smaller cantons display lower levels of engagement, showing existing inequalities in accessing the internet. This raises questions about the equity of e-commerce and the role of infrastructure in closing disparities. Digital in-

clusion should focus on not only the more populous but also the smaller and underserved regions, to allow consumers from all segments to enjoy online shopping.

7. Conclusion

This research highlights how detailed the exploration was concerning the effects of the COVID-19 pandemic on online consumers in Bosnia and Herzegovina. The results indicate that shopping habits during the pandemic have changed significantly due to factors such as people's digital readiness, accessibility of delivery services, and changing consumer needs. Online shopping experienced rapid growth during the pandemic and continued thereafter, demonstrating a long-term change in consumer behavior rather than merely a temporary shift. Demographic factors, particularly age and income, are important predictive factors of buying patterns. These aspects underscore the reality that businesses have to reconfigure their strategies along the emerging digital pathway to improve online facilities, logistics, and expectations of varying consumer segments.

7.1. Limitations and Future Research

Despite its valuable contributions, this research is not without limitations. The sample used in the research, although comprising diverse sections, does not capture the population of Bosnia and Herzegovina concerning more and less populated cantons and age divisions. Hence, these results may not be wholly generalizable. Future research should involve a larger and more representative sample so that the demographic spectrum is much broader, thereby including underrepresented regions and categories.

A cross-sectional approach was adopted in this study, which meant that consumer behavior was captured at just one point in time. In these contexts, it would be further interesting to make use of longitudinal studies as that would tell us how the trends for online shopping would change over time or with new technological advances or even with economic uncertainties. Other areas concerned with digital trust, perceived risk, marketing influence, or perhaps the impact of word of mouth via social media should also be addressed.

Finally, this study has not examined the impact of factors such as government policy, inflation, and global economic uncertainty on consumer purchasing decisions; however, such topics may considerably impact consumer buying decisions. Future studies taking these contextual effects into account could result in a better understanding of the complex factors shaping consumers' behavior in a post-pandemic society.

References

1. Ba, S., & Pavlou, P. A. (2002). Evidence of the effect of trust-building technology in electronic markets: Price premiums and buyer behavior. ***MIS Quarterly, 26***(3), 243-268. https://doi.org/10.2307/4132332
2. Ben Hassen, T., El Bilali, H., Allahyari, M. S., Karabašević, D., Radosavac, A., Berjan, S., Vaško, Ž., Radanov, P., & Obhodaš, I. (2021). Food behavior changes during the COVID-19 pandemic: Statistical analysis of consumer survey data from Bosnia and Herzegovina. ***Sustainability, 13***(15), 8617. https://doi.org/10.3390/su13158617

3. Bhatti, A., Akram, H., Basit, H. M., Khan, A. U., Naqvi, S. M. R., & Bilal, M. (2020). E-commerce trends during COVID-19 pandemic. International Journal of Future Generation Communication and Networking, 13(2), 1449-1452.
4. Dangelico, R. M., Schiaroli, V., & Fraccascia, L. (2022). Is Covid-19 changing sustainable consumer behavior? A survey of Italian consumers. Sustainable Development, 30(6), 1477–1496. https://doi.org/10.1002/sd.2322
5. Degli Esposti, P., Mortara, A., & Roberti, G. (2021). Sharing and sustainable consumption in the era of COVID-19. Sustainability, 13(4), 1903
6. Di Crosta, A., Ceccato, I., Marchetti, D., La Malva, P., Maiella, R., Cannito, L., Cipi, M., Mammarella, N., Palumbo, R., Verrocchio, M. C., & Di Domenico, A. (2021). Psychological factors and consumer behavior during the COVID-19 pandemic. ***PLOS ONE, 16***(8), e0256095. https://doi.org/10.1371/journal.pone.0256095
7. Dittmar, H., Long, K., & Bond, R. (2007). When a better self is only a button click away: Associations between materialistic values, emotional and identity–related buying motives, and compulsive buying online. Journal of Social and Clinical Psychology, 26(3), 334–361.
8. Hesham F, Riadh H, Sihem NK. What Have We Learned about the Effects of the COVID-19 Pandemic on Consumer Behavior? Sustainability. 2021; 13: 4304. https://doi.org/10.3390/su13084304
9. Jarvenpaa, S. L., Tractinsky, N., & Vitale, M. (2000). Consumer trust in an Internet store. ***Information Technology and Management, 1***(1-2), 45–71. https://doi.org/10.1023/A:1019104520776
10. Pestek, A., & Hadžijamaković, N. (2023). Customer attitudes toward e-commerce: Case of Bosnia and Herzegovina. In 8th International Scientific Conference CRODMA 2023 (pp. 79-88).
11. Sharma, S.; Rehman, A. (2012). Assessing the impact of web 2.0 on consumer purchase decisions: Indian perspective. International Journals of Marketing and Technology, 2(7), pp. 125-138, 2012.
12. Shaw, N., Eschenbrenner, B., & Baier, D. (2022). Online shopping continuance after COVID-19: A comparison of Canada, Germany and the United States. Journal of Retailing and Consumer Services, 69, 103100. https://doi.org/10.1016/j.jretconser.2022.103100
13. Srivastava, A., & Kumari, G. (2021). E-commerce in the post COVID-19 era: Challenges, opportunities, and consumers' preferences. ***ResearchGate***. https://www.researchgate.net/publication/356635273
14. Sun, X., Su, W., Guo, X., & Tian, Z. (2021). The impact of awe induced by COVID-19 pandemic on green consumption behavior in China. International Journal of Environmental Research and Public Health, 18(2), 543
15. Tiwari, R. (2020). A critical analysis of consumer's perception about online shopping. International Journal of Commerce and Management Research, 6(6), 36-37. https://www.managejournal.com
16. Uddin, B. (2020). Factors affecting consumers' internet shopping behavior during the COVID-19 pandemic: Evidence from Bangladesh. ***Chinese Business Review***, ***19***(3), 34-47. https://doi.org/10.17265/1537-1506/2020.03.003
17. UNICEF Bosnia and Herzegovina. (n.d.). ***Pandemija novog koronavirusa: Šta treba znati***. UNICEF. Retrieved January 16, 2025, from https://www.unicef.org/bih/covid19
18. Vittuari, M., Masotti, M., Iori, E., Falasconi, L., Toschi, T. G., & Segrè, A. (2021). Does the COVID-19 external shock matter on household food waste? The impact of social distancing measures during the lockdown. Resources, Conservation and Recycling, 174, 105815
19. Yang, H., Su, X., & Shion, K. (2023). Sustainable luxury purchase behavior in the post-pandemic era: A grounded theory study in China. ***Frontiers in Psychology, 14***, 1260537. https://doi.org/10.3389/fpsyg.2023.1260537

Sabina Čavalić, MA[1]
dr. sc. Ema Burić[2]
dr. sc. Admir Čavalić[3]

Review paper

MODERN SOCIAL MEDIA ADVERTISING TRENDS

Abstract

The paper analyzes current trends in social media advertising, with a special emphasis on the impact of new technologies on the formation of personalized marketing strategies. Personalization, based on artificial intelligence (UI), big data, blockchain technology, the Internet of Things (IoT), and wearables, has been recognized as a key direction of development of digital advertising. The subject and goal of the paper are to present current trends in social media advertising. Artificial intelligence enables automation and sophisticated analysis of consumer behavior, while big data reveals patterns and preferences of users, facilitating the creation of targeted communication. Blockchain provides security, transparency, and decentralization of data, while IoT and wearables enable continuous collection of information in real time, opening up new opportunities for personalized advertising. Although all these technologies bring numerous advantages, the paper also highlights challenges, especially in terms of privacy protection, data security, and the need for professional management of new tools. According to the results of the paper, it is recommended that companies continuously monitor technological trends in order to effectively achieve marketing goals in an increasingly complex digital environment.

Key words: *Advertising, Social Media, Trends.*

1 MA, IPI academy Tuzla, Kulina bana 2, Tuzla, sabina_cavalic@yahoo.com
2 PhD, Faculty of Economics, University of Zenica, Fakultetska bb, Zenica, ema.mustajbasic@gmail.com
3 PhD, IPI academy Tuzla, Kulina bana 2, Tuzla, admir.cavalic@yahoo.com

1. Introduction

In the modern digital environment, social media represent one of the most important channels for advertising, offering companies the opportunity to communicate with target groups immediately and efficiently. Technological advances, especially in areas such as artificial intelligence, large databases, blockchain technology, the Internet of Things (IoT), and wearable devices, are radically changing the approach to marketing and advertising. Personalization of content, as a dominant trend, enables the creation of messages that are adapted to the individual needs and interests of consumers. In this context, understanding new technologies and their implications becomes necessary for all market players. This paper examines how contemporary technological innovations are shaping social media advertising, analyzing the key trends and challenges that accompany this transformation.

This paper employs a qualitative methodological approach based on secondary analysis of relevant academic and professional literature in the fields of digital marketing, information technology, and communication. The methodology is aligned with the objective of offering an integrated theoretical overview of foundational concepts, the evolution of social media advertising, and current technological trends that are shaping its future. This review-based analysis enables the structuring of existing knowledge, the identification of key phenomena, and the establishment of a foundation for future empirical research in this domain. Such an approach provides insight into current practices and supports a critical reflection on the challenges and opportunities associated with the integration of advanced technologies into modern marketing strategies.

2. Social Media Advertising

A significant form of Internet application in a company's marketing communication is represented by the so-called social media, which are currently growing on the Internet and are ubiquitous (Martinčević, Vuković, Hunjet, 2020). Social media, virtual communities or online communities can be defined as groups of people who communicate in various ways, using blogs, comments, telephones, e-mails, and who share text, audio, video recordings, and photos for social, business, and educational purposes. This form of media is the foundation of the Web 2.0 phase of the Internet. Considering its popularity, there is increasing talk today about addiction to social media. Some countries, such as China, Vietnam, Turkey, Turkmenistan, and others, ban or largely censor social media on the Internet. Social media has experienced significant growth in the past few years, especially since 2005. Although the use of e-mail messages and Internet searches are among the main activities, there has been a significant increase in the use of social media. Today, we can hardly imagine everyday life without using at least one of the social media. They have become an everyday thing, a way of communicating with each other, a way of expressing emotions, attitudes, advice, and recommendations. Thus, social media is currently the fastest-growing socially active medium on the Internet (Osmanbegović, Hodžić, Suljić, 2014).

Social media services are focused on connecting users and building and veri-

fying online social content for communities of people who share the same or similar interests and activities, or who are interested in using the interests and activities of other people, and all this implies the mandatory use of software (Osmanbegović, 2011). The available literature offers a wide range of definitions of social media and the connection of marketing with them. Lančić defines social media as free web services that provide their users with one or two channels of communication with other users in the form of self-presentation and creating their audience or interactive communication like friends (Lančić, 2010). Bauer, in the chapter dedicated to social media, lists the following definitions (Bauer, 2013):

- Social media is any online application that enables equal, two-way communication; social media marketing operates on similar principles to word-of-mouth marketing, except that it is faster, has a much greater reach, and offers the option of participating for a few minutes a day to an entire day; it allows companies to introduce themselves to new audiences, create (open) new lines of communication, deepen relationships with existing users, and resolve crises.
- The social web is an online location where people with similar common interests can come together to share thoughts, comments, and opinions; it is the most effective way to communicate with consumers since the beginning of time; the world of social media is very democratic – everyone has the right to access and everyone can participate (Weber, 2009).
- Social media is collaborative and reciprocal; it represents an interactive dialogue (Bass, 2008).
- Social media is often defined as the “wisdom of the crowds”.
- Social media is a collaborative process through which information is created, shared, changed and destroyed (Evans, 2008).

From the above definitions, it can be concluded that it is a medium that is based on transparent, voluntary, democratically framed two-way communication, which, on the one hand offers the potential of "word-of-mouth" marketing, while, on the other hand, represents a threat to the company's image due to the inability to control it. On the other hand, social networks on the Internet provide the possibility of additional motivation of employees and their control by the company's management (Čavalić, 2014). What can be noticed is that social media, or rather their users, create trends that later spread throughout the rest of the Internet. Social media is not a homogeneous medium, so each of them needs special attention. Keitzmann and Hermkens list seven blocks that make up and differentiate each of the social media on the Internet: identity, conversation, sharing, presence, relationships, reputation and groups (Kietzmann et al., 2011). In connection with the above, Kaplan and Haenlein distinguish six types of social media (Kaplan, Haenlein, 2010):

- collaboration projects (Collaboration projects, e.g., Wikipedia),
- blogs and microblogs (Blogs and microblogs, e.g., Tumblr, Twitter, Blogger),
- content networks (Content Network, e.g., YouTube, Instagram, etc.),

- social networks (Social networking sites, e.g. Facebook, Google+, etc.),
- virtual worlds (Virtual Worlds, eg, World of Warcraft), i
- virtual social worlds (Virtutal Social Worlds, eg Second Life).

Collaborative projects like Wikipedia provide users with the opportunity to participate together in building certain structures on the Internet, such as the aforementioned online encyclopedia. Based voluntarily, such projects depend on the interest of users in participating in their construction. For a company, a collaborative project like Wikipedia provides the opportunity to present objective information to the public about its work, activities and fields of interest, or to offer information about its products, services or individuals who work for them. This is a fairly democratic form of social media. Blogs represent an older type of social media, present in the Web 1.0 phase, and through which the blog user provides a chronological overview of certain information. Microblog services are a newer type of blogs, and Twitter stands out primarily here, which allows users to post information in a limited form (maximum 140 characters on Twitter). In Bosnia and Herzegovina, unlike the countries of the region, Twitter is not yet as popular as other social media, but there are still signs of modest growth in the use of this form of social network. Worldwide, Twitter is currently growing, especially when it comes to public relations.

For a company, blogs and microblogs can be a good form of daily or weekly communication with users, or simply a space where informal information can be published. Content networks aim to create a platform for the exchange of content between users. Thus, users can use content networks to exchange photos, videos, texts or power-point presentations. The most popular among content networks is the YouTube video service, which allows companies to communicate with their target audience through videos. YouTube has proven to be extremely useful for archiving advertising messages (advertisements) of companies that have previously been broadcast on conventional media. Some companies create such messages only for the purpose of publishing on the YouTube video service. Social media are applications that allow users to connect by creating profiles with personal information, inviting friends and colleagues to have access to these profiles, and sending each other e-mails and instant messages (Kaplan, Haenlein, 2010). The most famous social network of this type is Facebook. In Bosnia and Herzegovina, a significant number of Internet users are members of some of the world's social networks, mostly Facebook. Thus, the Anatolia Agency (2024) states that there are 1,401,520 Facebook users in Bosnia and Herzegovina, which is 30.53 percent of the total population of the country.

Virtual worlds create an environment on the Internet that allows users to create their own personalities and communicate with other participants in the mentioned. The virtual environment is predefined, with a set of rules for its participants. One of the most popular virtual worlds is the Internet game "World of Warcraft", which is currently used by more than a million players worldwide. On the other hand, virtual social worlds give users greater freedom, without the existence of unnecessary rules, except for a few basic ones. Users can thus experiment with their own creativity, creating new environments and relationships

in them. In addition to the six basic types of social networks on the Internet, there are various subtypes.

According to Dazeinfo (2024) data from the fourth quarter of 2023, the leader in the field of social media on the Internet is Facebook with a global share of 51%. It is followed by Google+ with 28% and Yahoo with 15%, and Twitter with 4% market share. Some of the social media make money by charging membership fees for their use, while most use advertising for the purpose of making money, especially in the form of target marketing, which is made possible by the very nature of social media. The research power of social media is also interesting.

The Internet appearance of companies today, as well as marketing communication on the Internet, implies participation or presence on some social media. Kaplan and Haenlein (2010) offer basic guidelines for acting on the same:

- carefully choose social media,
- download or create your own social network,
- ensure consistency of activities on social media,
- media integration plan,
- ensure access for all.

There are thousands of different social media outlets across the Internet, so a company must choose where to actively participate. It is impossible to be on every social media outlet at the same time, as this would ultimately require unnecessary consumption of company resources. Accordingly, it is necessary to choose a social media outlet on the Internet where the company will carry out most of its communicative activities. This may also depend on the applied marketing strategy, which should take into account the specificities that arise in the operations of retail companies, and the necessity of applying modern methods in providing an efficient response to customer requests in retail (Sinanagić, Čivić, 2011). The general recommendation is to choose popular social media outlets, but also those that are relevant to the company's business. There is also the question of whether to participate in existing social media outlets on the Internet, using their positive externalities, or to create its own social media outlet that can be controlled and directed in the desired direction. After the company has chosen the social media outlets on the Internet on which it will appear, it is necessary to ensure harmony between activities on different social media outlets. This achieves a synergistic effect, a positive effect of harmonizing activities on a larger number of social media. Otherwise, it leads to confusion among users and a lack of conviction of companies' marketing efforts on the Internet. In addition to coordinating activities on different social media, it is important to try to implement a media integration plan for activities on conventional media with those on social media on the Internet. An example of this could be TV support for appearances on social media, most often in the form of mentioning the company's address on a given social media platform, and after a promotional appearance on television. It is worth mentioning the hashtag as an element of navigation on social media, which is often used to promote appearances on social media through conventional media.

It is important that each employee of the company has a certain access to the social media on which it appears. In doing so, it is necessary to take into account the administrator roles on social media. In addition to employees, an important factor in appearances on social media is also the users themselves. Bauer observes two extreme categories of social media users from the perception of companies that have an presence on social media. The first are detractors and, as stated, they should not be confused with those who do not like companies. Detractors consider it their personal mission to constantly try to harm the company/brand in every way possible, most often because they think they are doing the right thing (Bauer, 2013). Evans (2008) notes that brand detractors are people whose mission is to try to cause (public) harm to the company no matter what it does. Accordingly, the company should accept the detractors and their activities as given, without the possibility of change, but try to present their side of the story, i.e., to present information that offers arguments in favor of the company's image. In addition to detractors, there are also evangelists, people whose attachment to a particular brand or company is such that they are willing to invest their energy, time, and sometimes money for it (Bauer, 2013). Evangelists are useful for the steady growth of the popularity of companies, especially through word-of-mouth marketing.

The Wall Street Journal, in its front-page article, questions the importance of social media on the Internet for companies' marketing activities. The article cites Gallup research showing that 61% of consumers believe that social media on the Internet has no influence on their purchasing decisions, as well as a Nielsen Holdings NV study that concludes that global consumers trust promotional messages on television, print media, radio, billboards and movie spots more than social media promotions (Elder, 2014).

Using social media on the Internet represents one of the most difficult challenges for marketers today. Namely, it is very difficult for marketers to deal with social media, and the reason for this is their rapid development and the excessive flow of information, which they cannot process in a timely and useful manner. Social media on the Internet, as a new area for the implementation of marketing activities, represents a challenge, where there is a lot of information, which often does not lead to the right conclusions. Accordingly, companies need to invest additional efforts in understanding social media on the Internet and analyzing its relevance for their business. The most famous social media platforms vary depending on region and target audience, but among the most recognizable globally are:

- **Facebook**: Facebook was founded in 2004 and is currently the largest social networking service based on global reach and total active users (Milić, 2020). Statista estimates (2023) that over 3 billion users worldwide use Facebook as a social media platform. Facebook is the largest social network in the world that allows users to share content, communicate with friends, and follow brand pages. Facebook allows users to not only communicate with each other but also to share photos, reveal personal information, comment on a topic, or play games. The social network Facebook, as the most popular social network, can be used for

various reasons, and these reasons create approaches to addressing consumers, which indirectly leads to the generation of sales and profits (Gardašević, Čirić, Carić, 2018). As the largest social media platform, Facebook has changed and continues to change the nature of human relationships (Muise, Christofides, Desmarais, 2009).

- **Instagram**: A popular platform for sharing photos and videos. It is particularly popular among younger audiences and creatives. Instagram is one of the world's largest mobile social media platforms, and its benefits lie in increasing brand awareness through the promotion of visual content and a potentially large audience (Stokes, 2018). With over 127 million active Instagram users worldwide in 2023, the US is the leading market for photo sharing based on the number of users. Cristiano Ronaldo has one of the most popular Instagram accounts and is the most followed person on the photo-sharing platform with 628 million followers.
- **Twitter** (now "X"1): A social media platform that focuses on short messages called "tweets." Twitter is used for quick sharing of information, communication, and keeping up with current events. Twitter allows companies to connect with customers in near real time, which gives them the opportunity to build and improve customer relationships. Several companies use Twitter as a tool for research, marketing, and customer service. Marketing on Twitter requires a lot of effort and time. Profiles must have interesting content and ideas so that followers do not lose interest quickly. Followers should not be flooded with tweets about offers and discounts every hour, or even every day (Curran, O'Hara, O'Brien, 2011). Twitter has been particularly relevant in the last year when it has experienced an extraordinary business and overall transformation. It is important to note that today, some companies use Twitter to share information and communication; unfortunately, such companies are extremely few.
- **LinkedIn**: It is one of the largest social media platforms in the world (Auradkar et al., 2012) and probably the largest professional social network used for connecting professionals, job searching, recruiting, and networking. It is also particularly important for gathering business information (Bradbury, 2011). This makes LinkedIn a unique data ecosystem (Sumbaly, Kreps, Shah, 2013). LinkedIn can (Stokes, 2018): help a company engage and connect with industry influencers; provide a range of data for market research; enable companies to track prospects and customers; enable companies to clarify what they represent, monitor, and learn more about the media covering their industry; and help position a business as a leader in its industry. LinkedIn has become popular among retail chains that have created profiles on this platform for business networking, customer engagement, job searching, and recruiting.
- **YouTube**: It was founded in 2005 by PayPal employees. After two years, it was acquired by Google (Arhurs, Drakopoulou, Gandini, 2018). YouTube is the largest video-sharing platform in the world (Wattenhofer, Wattenhofer, Zhu, 2012). Users can publish, view and share videos on various

1 The new owner of Twitter, Elon Musk, has changed the name of this social media to "X". The work will use the previous name Twitter, with the understanding that users still call it that name.

topics. This represents a combination of the creation and distribution of original content and classic social media (Chau, 2011). This is why YouTube is particularly interesting in terms of education (Snelson, 2011). Also in terms of health or health advice (Madathil et al., 2015). Today, retail chains use YouTube to introduce the company to users or potential customers, to the company's social responsibility towards the community and the environment, to present discounts or promotions they offer. Companies use this social media to promote their business, that is, they use paid ads with a target group that is of interest to them, so we can see that while watching a certain show via YouTube media, it is interrupted by a sponsored ad from a company whose interest is to be seen by users who follow a certain content and which is certainly related to the show being watched. Recently, sponsored ads that the user cannot just interrupt have become popular, they are forced to watch them to the end, in order to continue watching the content they have started. This is certainly a benefit that the YouTube platform provides to advertisers so that it does not happen that the user "skips" the ad. Of course, a company that invests in this type of advertising can clearly see through the reports it receives how many users "skipped" the ad, and how many stayed with it, and based on that, it decides on the strategy to apply when sponsoring content next.

- **Snapchat**: An application for sharing photos and videos that are automatically deleted after a certain period of time. This provides a high level of privacy (Utz, Muscanell, Khalid, 2015) but also seems illogical from the position of today's paradigm regarding adequate data storage (Soffer, 2016). As a result, data is lost and unavailable, which is certainly one of the disadvantages. It is known for its filters and effects for photos. It is also known as a social media that strives for maximum personalization according to the needs of users (Vaterlaus et al., 2016).
- **TikTok**: A platform for short videos that often include dance, humor, and challenges. It is currently the fastest-growing social media among young people (McCashin, Murphy, 2023). However, there are trends of increasing popularity of this social media among the older population. It can also be used for a number of other things, such as improving the reading culture among young people (Jerasa, Boffone, 2021). According to De Leyn et al. (2021), TikTok is particularly popular among young people, which is why it is often the subject of research regarding the protection of the integrity of young people (e.g., the privacy of young people aged 8 to 12 who use TikTok). Also, due to its unpredictability in the form of an extremely powerful algorithm, like other social media, it requires new research approaches when analyzing it (Harriger, Thompson, Tiggemann, 2023). For retail chains to be as close as possible to the younger population, considering them as future customers who will manage their own budgets at a certain time, they try to approach them through TikTok media, publishing interesting/entertaining content that does not necessarily represent all current promotions, but image campaigns or even thematic promotions (product promotions) that concern this population.

- **Reddit**: A social media platform structured around topic-based communities known as "subreddits," where users engage in discussions, share experiences, and rate content through an upvote/downvote system. What sets Reddit apart is its semi-anonymous user environment and the emphasis on community-driven content curation. This structure supports diverse, interest-based interaction, which has been shown to foster high engagement and information diversity. Reddit enables bottom-up diffusion of information and supports unique network topologies that can influence content visibility, virality, and advertising strategies. (Medvedev et al., 2020)
- **Pinterest**: A visual discovery platform focused on the curation and sharing of themed content collections. Unlike other platforms where interaction is driven by social connections, Pinterest usage is centered on personal goals, inspiration, and future planning-making it particularly valuable for brands targeting consumer intention. Research shows that user engagement on Pinterest is significantly influenced by perceived value, platform loyalty, and trust, all of which are strong predictors of purchase intention. For marketers, this implies that consistent value creation and brand authenticity on Pinterest can lead to tangible behavioral outcomes. (Sethna et al., 2021)
- **Threads**: A text-oriented platform developed by Meta is designed to replicate the conversational nature of Twitter while integrating seamlessly with Instagram's user base. Unlike traditional microblogging platforms, Threads emphasizes user identity continuity and cross-platform visibility. Early analyses suggest that Threads leverages Meta's existing ecosystem to create a space for more controlled, personalized, and civil discourse—elements that are particularly attractive for brands aiming to maintain reputation and targeted reach in an increasingly fragmented digital landscape. (Zhang et al., 2024)

These are just some of the most famous social media, but there are many other platforms that have a significant impact in different regions and among certain target groups. The basic characteristics of social media are: interactivity, information and system quality, sharing mechanism, costs, social interactions, target market, and irritability (Handanagić, 2023). Interactivity, as a combination of rich content, active intelligence, and collaborative communication, creates a compelling user experience in business environments (Handanagić, 2023). Ha and Jame (1998) explored the concept of interactivity and proposed that it be defined as the degree to which the communicator and the audience respond to each other's communication needs in terms of five dimensions of the construct. Platform quality includes information quality (providing valuable data and information in a timely manner) and system quality (maintaining reliable and accessible functionality that helps users search and share information quickly and conveniently) (Zeithaml, Berry, Parasuraman, 1996).

Knowledge sharing mechanisms facilitate the transfer of knowledge between people and are usually able to increase the value of knowledge through the acceleration and dissemination of knowledge. Links between members within

an organization can create a knowledge flow for the exchange of specific concepts and understandings (Tsai, 2000). The main advantage of social media marketing is related to costs. Most social media sites are free to access, create profile information, and post. Advertising marketing campaigns through traditional media can cost up to several million, while advertising through social media is quite variable and usually offers a higher return on investment. A combination of both advertising methods can certainly be the most effective strategy, depending on the company's goals and target audience. Low costs are the main advantage of advertising on social media (Arsath, 2018). Most social media sites offer free access, profile creation and posting information (Arsath, 2018). Social media allows for easier monitoring and analysis of user reach and engagement. Aware of the fact that users spend more and more time on social media, interactions between users represent one of the most important factors of these media, because individuals are more likely to take into account advice and information shared online, and such information can directly influence purchase intentions, even if it is received from purely virtual sources (Handanagić, 2023). Companies use targeted advertising to reach customers who are most interested in what the company offers, all thanks to targeting the target group and using targeted advertising tools. Irritability is a term defined as the level of unrelated information from mobile advertising messages that affects consumer discomfort (Kim, Han, 2014). Irritability is a state of feeling irritated, impatient or angry (Ducoffe, 1996). The presence of irritability can reduce the effectiveness of advertising (Ducoffe, 1996). The only negative dimension of consumers' relationship to advertising is irritability (Okazaki, 2004).

3. Modern Social Media Trends

There are many trends in social media advertising. Understanding that social media is absolutely dependent on new technologies, it is clear why its development automatically has an impact on the change in advertising. One of the key trends in social media advertising is the trend of personalization. It is about the activities of designing and manufacturing in a way that matches the preferences of consumers. As stated by Shobhana and other authors, future personalization of this type will be based on artificial intelligence, large databases, blockchain technology, the Internet of Things, as well as new objects that will be developed to explore the reality around us. Based on the above, new ways of exploring and adapting to personal experiences, both live and online, will be developed (Shobhana et al., 2022). Some of the trends in social media advertising are explained below.

Artificial intelligence (AI) is a branch of computer science that deals with the creation of computer systems that are capable of performing tasks that require human intelligence. This can include various techniques like machine learning, deep learning, natural language processing, heuristic search, and more. It is about the centuries-old idea of man to have a machine that will think (Putica, 2018). The inclusion of new technologies, especially those based on different principles and applications of artificial intelligence (AI), forces modern society to rethink and reorganize existing systems. It can be said that the organ-

ization of society is a picture of the possibilities of the technology available to society. A new communication revolution has already begun, and people are facing new challenges. Artificial intelligence can help professions based on communication, such as public relations, but at the same time, it requires even more knowledge and expertise in order to properly understand and apply the obtained results (Tomić, Volarić, 2022). The goal of artificial intelligence is to create systems that can perceive the environment, learn from experience, make decisions, and solve problems in a way similar to human thinking. This technology has wide applications in areas such as medical diagnostics, autonomous vehicles, finance, robotics, gaming, pattern recognition, and more. When it comes to advertising, it can be particularly useful in the context of creating personalized ads (Mogaji, Olaleye, Ukpabi, 2019). Like any other technology, it is neither good nor bad in itself, but it depends on the users who use it (Tomić, Volarić, 2022).

Big data refers to the vast amounts of data that are generated, collected, and stored in digital form. This data presents a challenge for advertising in that new models and approaches to advertising must be created (Malthouse, Li, 2017) in order to adequately utilize the data. This data is characterized by three main characteristics known as the "3Vs": volume, velocity, and variety. Volume: Big data typically involves vast amounts of data, sometimes in the terabytes or petabytes, originating from diverse sources such as social media, sensors, mobile devices, the internet, transactional data, and more. Velocity: Data is generated and arrives rapidly. The speed of data collection can be extremely high, requiring technologies that can process data in real time or near real time. Variety: Big data comes in a variety of formats and structures, including structured data (e.g. databases), unstructured data (e.g., text documents, audio, and video), semi-structured data (e.g. XML, JSON), and images, graphs, tables, and more. In addition to these three "Vs", some add other characteristics such as validity, variability, complexity, and value. Big data analysis can reveal useful insights, patterns, and trends that can help organizations make better business decisions, understand user behavior, personalize products and services, and optimize processes. Based on the collected data, it is possible to understand the behavior and spending habits of individual consumers (Mohbey, Kumar, Koolwal, 2020). Personal data and information that can be used to personalize ads are particularly important for advertising (Mogaji, Olaleye, Ukpabi, 2019). However, managing and analyzing big data requires advanced data processing techniques, such as distributed data storage and processing systems, machine learning and deep learning techniques, word processing algorithms, and the like. Also, care must be taken to protect the "ecology" of relationships on social media, which can be compromised by the concept of big data (Coludry, Turow, 2014).

Blockchain technology. Blockchain technology is a new technology which represents a platform and foundation for trading cryptocurrencies, as well as the implementation of smart contracts (Di Pierro, 2017). Blockchain technology is an innovative system for storing and exchanging data that enables a secure, transparent, and decentralized record of transactions. Originally developed for

the needs of the digital currency Bitcoin, blockchain has now found application in many other areas. Some of how Blockchain technology is applied are:

- **Cryptocurrencies**: Blockchain is best known as the basis for cryptocurrencies such as Bitcoin and Ethereum. It enables secure and decentralized execution of financial transactions.
- **Financial Services**: Blockchain is used to reduce costs and increase the speed of financial transactions, including cross-border transfers, post-trade processing, and digital assets.
- **Supply Chain Management**: Tracking products throughout the entire supply chain becomes more transparent and secure, allowing all participants to track the authenticity and origin of a product.
- **Healthcare**: Blockchain can improve the security and privacy of health data, enabling the secure exchange of medical information between healthcare institutions.
- **Legal and Real Estate**: Smart contracts can automate processes such as contract formation and real estate transactions, reducing the need for paper documents and intermediaries.
- **Digital Identity**: Blockchain can enable secure and decentralized identity verification, reducing the risk of identity theft and improving user privacy.

Blockchain technology represents a revolution in the way we store and exchange data. Its key characteristics – immutability, transparency, security, and the possibility of automation – make it extremely useful in many industries. Although blockchain is still not without flaws and challenges, such as initiatives to form so-called Ponzi schemes (Mataković, Mataković, 2018), its further application and development promise to transform many aspects of business and society.

Internet of Things. Kevin Ashton first coined the phrase Internet of Things in 1999 to describe a system in which the Internet is connected to physical objects using sensors (Šipek, 2022). The Internet of Things (IoT) represents a network of physical devices, vehicles, household appliances, and other objects that are equipped with sensors, software, and other technologies that allow them to connect and exchange data over the Internet. In the future, these objects are expected to communicate with each other in the process of "M2M" - machine-to-machine communication (Chen, 2012). The process of Internet of Things devices is as follows (Šipek, 2022): Smart devices collect and forward data via the Internet to other devices. The data is analyzed centrally in data centers and cloud services or using edge computing. The final information and instructions based on the data analysis are returned to other IoT devices. The goal of IoT is to create a "smart" environment in which devices can communicate with each other, collect data (locations, consumer purchase history, etc.) (Yamin, 2022), and automate processes. The Internet of Things (IoT) represents a revolution in the way we connect and manage devices in our daily lives and businesses. Its ability to connect physical objects with the digital world opens up new opportunities for improving efficiency, security, and quality of life. However, in order to fully utilize the potential of IoT, it is necessary to overcome

challenges related to security, interoperability, and scalability. It is important to emphasize that IoT, like the entire Internet, tends to evolve slowly (Chen, 2012), which makes its capabilities more significant for advertising purposes.

Wearables. Wearables are electronic devices worn on the body as part of clothing or accessories, such as watches, bracelets, glasses, and similar items. These devices are equipped with sensors and software that collect and analyze data, providing users with information and functionalities that improve their daily experience. The devices are in continuous communication with social media (Gupzs et al., 2020), which is changing the nature of advertising. Wearables often offer personalized advice and recommendations based on the collected data, which can improve the user experience and results, but also affect persuasion (persuasive nature of advertising) (Tham, 2018). Wearables have become an integral part of everyday life, providing users with various functionalities that improve health, productivity, and overall well-being. With further technological advancements, wearables are expected to become even more integrated into our lives, offering new opportunities and solutions. However, it is important to emphasize that these devices are still lagging behind conventional electronics and have not yet been sufficiently accepted by customers (Jannek, 2023). This also has the consequence that these devices are not as present within the modern advertising process. The company should follow each of the above trends in advertising, as well as new, future ones, all with the aim of more adequately achieving marketing and advertising goals.

4. Conclusion

Contemporary trends in social media advertising show a clear shift towards personalization, automation, and the use of advanced technologies. Artificial intelligence, big data, blockchain, IoT, and wearables enable a deeper understanding of consumer behavior and the creation of content that is precisely targeted and relevant. However, such technological progress also raises numerous questions regarding privacy protection, data security, and advertising ethics. In order to maintain a competitive advantage, companies must continuously monitor technological changes and invest in the development of professional capacities. In the digital age, the success of advertising depends not only on innovative tools but also on the ability to apply them responsibly and by user expectations.

Although this paper is conceptual and review-based, it serves as a foundation for further empirical research. Future studies could explore the measurable impact of technological personalization on consumer attitudes, purchasing behavior, and brand trust. Additionally, interdisciplinary research combining marketing, psychology, ethics, and data science would contribute to a deeper understanding of how to balance innovation with user protection in digital advertising environments. Such research would be valuable for both academic discourse and practical application in an increasingly complex and dynamic media landscape.

References

1. Arsath A.M., (2018), Social Media Marketing: Advantages and Disadvantages. Shanlax International Journal of Management, 6, pp. 152–158.
2. Arthurs J., Drakopoulou S., & Gandini, A. (2018), Researching YouTube, Convergence, 24(1), 3-15., https://doi.org/10.1177/1354856517737222 str. 3.
3. Auradkar A. et al., "Data Infrastructure at LinkedIn," IEEE 28th International Conference on Data Engineering, Arlington, (2012), VA, USA, pp. 1370-1381, doi: 10.1109/ICDE.2012.147. keywords: {LinkedIn; Indexes; Companies; Servers; Routing; Pipelines},
4. Bass C.B., (2008), Social networking for newbies, Incentive Vol.182, Issue 4., str. 30.
5. Bauer I., (2013), Digitalni marketing, Zavod za udžbenike, Beograd
6. Bradbury D., (2011), Data minining with LinkedIn, Computer Fraud & Security, (2011), Issue 10, pages 5-8, str. 5.
7. Čavalić A., (2014), Menadžerska vještina komuniciranja sa osvrtom na Internet komunikaciju, Zbornik radova sa 2 međunarodnog simpozija „Izazovi finansijsko-računovodstvene i menadžerske profesije u Bosni i Hercegovini – mogućnosti i ograničenja", Finconsult, Tuzla, str. 266.
8. Cbs News (2024), Elon Musk confirms Twitter's transformation is complete. It's now X.com, cbsnews.com, dostupno na: https://www.cbsnews.com/news/elon-musk-confirms-twitters-transformation-complete-its-now-x-com/ (2.4.2024.)
9. Chau C., (2011), YouTube as a participatory culture, Volume2010, Issue128 Special Issue: New Media and Technology: Youth as Content Creators Winter 2010, Pages 65-74.
10. Chen Y. K., (2012), "Challenges and opportunities of internet of things," 17th Asia and South Pacific Design Automation Conference, Sydney, NSW, Australia, pp. 383-388, doi: 10.1109/ASPDAC.2012.6164978.
11. Coludry N., Turow J., (2014), Advertising, Big Data, and the Clearance of the Public Realm: Marketers New Approaches to the Content Susidy, International Journal of Communication 8, str. 1710.
12. Cunjak Mataković I., i Mataković H., (2018), Kriptovalute - sofisticirani kodovi manipulacije, International Journal of Digital Technology & Economy, 3. (1.), 23-37. Preuzeto s https://hrcak.srce.hr/216173 , str. 23. (20.6.2024.)
13. Curran K., O'Hara K., O'Brien S., (2011), The Role of Twitter in the World of Business, International Journal of Business Data Communications and Networking, 7(3), pp. 1-15.
14. Dazeinfo, (2024), Social Login Q4: Facebook Inc. (FB) Retains Its Share Of 51%, Ad-Free Networking Site Google Plus' Share Increased To 28%, http://www.dazeinfo.com/2014/02/11/social-login-q4-facebook-inc-fb-retains-share-51-ad-free-networking-site-google-plus-share-increased-28-report/ (10.06.2024.)
15. De Leyn, T., De Wolf, R., Vanden Abeele, M., & De Marez, L. (2021), In-between child's play and teenage pop culture: tweens, TikTok & privacy, Journal of Youth Studies, 25(8), 1108–1125. https://doi.org/10.1080/13676261.2021.1939286 str.1108.
16. Di Pierro M., (2017), What is the Blockhain?, Computing in Science & Engineering (Volume: 19, Issue: 5.), str. 92.
17. Ducoffe R.H., (1996), Advertising Value and Advertising on the Web, Journal of Advertising Research, 36(5), pp. 23.
18. Elder J., (2014), Social Media Fall Short Of Early Marketing Goals, The Wall Street Journal, 24.06.2014., Europe edition, str. 16.
19. Evans D., (2008), Social Media Marketing – An Hour a Day, Wiley publishing, Inc., Indianapolis, str. 34.
20. Gardašević J., Ćirić M., Carić M., Razumevanje motiva korišćenja društvenih mreža u funkciji unapređenja komunikacije sa potrošačima, Marketing, 2018., pp. 311-320.
21. Gupzs M., Dinhs N., Dinhh P. Hui-Ern D., (2020), Gender differences in the wearable preferences, device and advertising value perceptions: smartwatches vs. fitness trackers, Chuah International Journal of Technology Marketing 2020, 14:2, 199-225.
22. Ha L., i Jame E., (1998), Interactivity Reexamined: A baseline Analysis of Early Business Web Site, Journal of Boradcasting and Electronic Media. 42(4), pp. 457- 474.

23. Handanagić L., (2023), Determinante stavova potrošača prema oglašavanju u društvenim medijima, master rad, dostupno na: https://ebiblioteka.efsa.unsa.ba/xmlui/handle/EFSA/589 , str. 17.
24. Internet restrikcije: Zemlje koje su zabranile društvene mreže, http://novovrijeme.ba/internet-restrikcije-zemlje-koje-su-zabranile-drustvene-mreze/ (17.06.2024.)
25. J., Mitchell Vaterlaus, Kathryn Barnett, Cesia Roche, Jimmy A., (2016), Young, "Snapchat is more personal": An exploratory study on Snapchat behaviors and young adult interpersonal relationships, Computers in Human Behavior, Volume 62, Pages 594-601, ISSN 0747-5632, https://doi.org/10.1016/j.chb.2016.04.029 str 594.
26. Jannek Kjøll Sommer, 3 - Why consumers resist wearables and what to do about it?, Editor(s): Jane McCann, David Bryson, In The Textile Institute Book Series, Smart Clothes and Wearable Technology (Second Edition), Woodhead Publishing, 2023, Pages 67-80, str. 67.
27. Jennifer A. Harriger, J. Kevin Thompson, Marika Tiggemann, TikTok, TikTok, the time is now: Future directions in social media and body image, Body Image, Volume 44, 2023, Pages 222-226, ISSN 1740-1445, str. 222.
28. Jerasa S., Boffone T., (2021), BookTok 101: TikTok, Digital Literacies, and Out-of-School Reading Practices, Volume65, Issue3 November/December 2021 Pages 219-226, str. 219.
29. Kaplan A.M, Haenlein M., (2010), Users of the world, unite! The challenges and opportunities of Social Media, Business Horizons, 53, 59—68, str. 62.
30. Kietzmann J. H., Hermkens K., McCarthy I. P., Silvestre B. S., (2011), Social media? Get serious! Understanding the functional building blocks of social media, Business Horizons vol. 54., str. 243.
31. Kim Y. J., i Han J., (2014), Why Smartphone Advertising Attracts Customers: A Model of Web Advertising, Flow, and Personalization. Computers in Human Behaviour. 33, pp. 256–269.
32. Lančić R.D., (2010), Novi mediji i odnosi s javnošću, Medijske studije, 1 (1-2), str. 159.
33. Madathil KC, Rivera-Rodriguez AJ, Greenstein JS, Gramopadhye AK., (2015), Healthcare information on YouTube: A systematic review. Health Informatics Journal, 21(3):173-194. doi:10.1177/1460458213512220, str. 173.
34. Malthouse, E. C., & Li H., (2017), Opportunities for and Pitfalls of Using Big Data in Advertising Research, Journal of Advertising, 46(2), 227–235. https://doi.org/10.1080/00913367.2017.1299653 , str. 227.
35. Martinčević E., Vuković D., Hunjet A., (2020), Blogeri i influenceri, fenomeni utjecaja na potrošače modnih odjevnih proizvoda, CroDiM: International Journal of Marketing Science, Vol. 3 No. 1, 2020., str. 23.
36. McCashin D., Murphy CM., (2023), Using TikTok for public and youth mental health – A systematic review and content analysis. Clinical Child Psychology and Psychiatry, 28(1):279-306. doi:10.1177/13591045221106608, str. 279.
37. Milić N., (2020), Društvene mreže kao segment digitalnog marketinga u bankarstvu, Trendovi u poslovanju, naučno-stručni časopis, 16 (2), dostupno na: https://scindeks-clanci.ceon.rs/data/pdf/2334-816X/2020/2334-816X2002057M pdf, str. 66.
38. Mogaji E., Olaleye S., Ukpabi D., (2019), Using AI to Personalise Emotionally Appealing Advertisement, Digital and Social Media Marketing, Springer, str. 137.
39. Mohbey K.K., Kumar S., Koolwal V. (2020), Advertisement Prediction in Social Media Environment Using Big Data Framework. In: Tanwar, S., Tyagi, S., Kumar, N. (eds) Multimedia Big Data Computing for IoT Applications. Intelligent Systems Reference Library, vol 163. Springer, Singapore. https://doi.org/10.1007/978-981-13-8759-3_12 str. 323.
40. Muise A, Christofides E, Desmarais S. (2009), More information than you ever wanted: does Facebook bring out the green-eyed monster of jealousy? CyberPsychology & Behavior; 12:441–444.
41. Okazaki S., (2004)., How Do Japanese Consumers Perceive Wireless Ads ? A Multivariate Analysis, International Journal of Advertising. 23, pp. 429–454.
42. Osmanbegović E., (2011), Aspekti ranjivosti korisničkih podataka na društvenim mrežama – slučaj Bosne i Hercegovine, Tranzicija, Vol.13 No.28, str. 70 – 79.
43. Osmanbegović E., Hodžić K., Suljić M., (2014), Model for Estimating the Potential of Social Networking Sites Usage in Tourism Industry in Bosnia and Herzegovina, Journal of Knowl-

edge Managment, Economics and Information Technology, Vol. IV, Issue 1, str. 3.
44. Putica M., (2018), Umjetna inteligencija: Dvojbe suvremenog razvoja, Hum, XII, 20, str. 198.
45. Shobhana C., Sanjeev V., Weng M.L., Satish K., Naveen D., (2022), Personalization in personalized marketing: Trends and ways forward, Wiley Online Library
46. Šipek D., (2022), Što je IoT ili internet of things?, dostupno na: https://duplico.io/sto-je-iot-ili-internet-of-things/ (20.6.2024.)
47. Snelson C., (2011), YouTube Across the Disciplines: A Review of the Literature, scholarworks.boisestate.edu, dostupno na:https://scholarworks.boisestate.edu/edtech_facpubs/11/ (3.4.2024.)
48. Soffer O., (2016), The Oral Paradigm and Snapchat. Social Media + Society, 2(3)., https://doi.org/10.1177/2056305116666306
49. Statista, (2023), Number of monthly active Facebook uaers, dostupno na: https://www.statista.com/statistics/264810/number-of-monthly-active-facebook-users-worldwide/ (20.4.2024.)
50. Statista, (2023), Number of monthly active Facebook users worldwide as of 4th quarter 2023,
51. Statista, (2024), Instagram accounts with the most followers worldwide: https://www.statista.com/statistics/1024769/instagram-users-usa/ (15.5.2024.)
52. Stokes R., (2018), E-marketing – The essential guide to marketing in a digital world, Cape Town:The Red & Yellow Creative School of Business
53. Sumbaly R., Kreps J., Shah S., (2013), The big data ecosystem at LinkedIn, SIGMOD '13: Proceedings of the 2013 ACM SIGMOD International Conference on Management of Data, https://doi.org/10.1145/2463676.2463707, str. 1125.
54. Tham J., (2018), Persuasive-Pervasive Technology: Rhetorical Strategies in Wearables Advertising, International Journal of Semiotics and Visual Rhetoric (IJSVR) 2(1), https://www.igi-global.com/article/persuasive-pervasive-technology/202475 (16.3.2024.)
55. Tomić Z., Volarić T., (2022), Umjetna inteligencija u odnosima s javnošću, South Eastern European Journal of Communication, Vol. 4 No. 2, 2022., str. 7.
56. Tsai W., (2000), Social Capital, Strategic Relatedness and the Formation of Intra organtional Linkages. Strategic Management Journal. 21(9), pp. 925-939.
57. Utz S., Muscanell N., Khalid C., (2015), Snapchat Elicits More Jealousy than Facebook: A Comparison of Snapchat and Facebook Use, Cyberpsychology, Behavior, and Social Networking, Vol. 18, No. 3.
58. Wattenhofer M., Wattenhofer R., Zhu Z., (2012), The YouTube Social Network, Vol. 6 No. 1 (2012): Sixth International AAAI Conference on Weblogs and Social Media
59. Weber L., (2009), Marketing to the Social Web – How Digital Customer Communities Build Your Business, John Wiley & Sons
60. Wei, Yamin, (2022), Advertising Image Design Skills of E-Commerce Products in the Context of the Internet of Things, Mobile Information Systems, 1022825, 11 pages, https://doi.org/10.1155/2022/1022825
61. Zeithaml V., Berry L.L., i Parasuraman A., (1996), The Behavioural Consequences of Service Qualit, Journal of Marketing, 60, pp. 31-46.
62. Zhang, P., He, Y., Haq, E. U., He, J., & Tyson, G. (2024, September). The emergence of threads: The birth of a new social network. In International Conference on Advances in Social Networks Analysis and Mining (pp. 69-78). Cham: Springer Nature Switzerland.
63. Sethna, B. N., Hazari, S., & Brown, C. O. M. (2021). Investigating value, loyalty, and trust as determinants of purchase intention on the Pinterest social media network. International Journal of Electronic Marketing and Retailing, 12(2), 171-195.
64. Medvedev, A. N., Lambiotte, R., & Delvenne, J. C. (2017). The anatomy of Reddit: An overview of academic research. Dynamics on and of Complex Networks, 183-204.

Dino Arnaut, PhD[1]
Damir Bećirović, PhD[2]

Review paper

A MODEL FOR THE ECONOMIC EMPOWERMENT OF GIRLS AND YOUNG WOMEN

Abstract

This paper examines the multifaceted factors influencing economic empowerment and entrepreneurship among young women, focusing on community role models, policy and legal incentives, the digital economy, access to capital, business training, and integrated capital-plus-training interventions. Empowered women leaders serve as vital community catalysts, inspiring and expanding economic opportunities, especially in marginalized contexts. Supportive government policies and legal frameworks—ranging from streamlined business registration to multisectoral initiatives—play a crucial role in fostering inclusive entrepreneurial ecosystems. The rapidly growing digital economy offers alternative, low-barrier platforms for income generation and innovation, enhancing economic independence and gender equality, although digital divides remain a challenge. Access to capital, particularly through microloans and grants, shows mixed results; while small infusions rarely boost profitability for subsistence female microenterprises, targeted, sustained capital combined with training can lead to significant, lasting income improvements, especially among ultra-poor women. Business training alone often improves practices but less frequently translates into profitability or business survival, with better outcomes observed for newly established firms and larger enterprises. Integrated capital-plus-training programs emerge as the most promising approach, although social and household dynamics—such as financial pressures on married women—may limit women's ability to capitalize on these opportunities. Addressing structural barriers and tailoring interventions to women's specific contexts are essential to unlock their full entrepreneurial potential.

Key words: *Economic Empowerment, Women's Entrepreneurship, Social Entrepreneurship, NGOs.*

1 Professor at International Business Information Academy Tuzla, Bosnia and Herzegovina, arnaut.dino@gmail.com
2 Professor at International Business Information Academy Tuzla, Bosnia and Herzegovina, damirbeci@hotmail.com

1. Introduction

The Human Development Report (HDR), published annually by the United Nations Development Programme (UNDP), has adopted a broader set of indicators to assess women's empowerment. Rather than focusing solely on income and financial security as key development metrics, it also incorporates education and healthcare as core indicators of progress. These measures of well-being have proven to be directly impactful and thus more effective in assessing actual advancement (Sen, 1992). Consequently, broader discussions on women's empowerment now recognize multiple dimensions that must be studied individually, including the following (Sharma & Das, 2021):

- **Economic empowerment** refers to women's financial independence. This form of empowerment gives women greater autonomy over their living standards, purchasing decisions, and life choices, allowing them more control over their own lives. It serves as a critical indicator of overall empowerment, particularly in patriarchal societies, by reducing dependency. Gender equality is essential for designing inclusive, long-term policy strategies (Jha, 2009). However, women often face economic deprivation, exacerbated by limited employment opportunities and restrictive traditional social norms.
- **Legal empowerment** involves the presence of strong legal frameworks that protect women's rights and safety. This type of empowerment is vital for enabling women to pursue their life goals freely, without fear of violence or exploitation. Violence against women is frequently used as a means of control, especially by individuals in positions of power. Such incidents are often underreported—official statistics frequently represent only a quarter of actual cases—due to the stigma and potential legal repercussions for the victims' families.
- **Social empowerment** pertains to the creation of social structures that support women's holistic development. This includes access to healthcare, education, support from NGOs, and dedicated women's centers. Exploring social empowerment is crucial, as cultural and societal factors often play a decisive role in shaping women's ability to make independent choices. Elements such as participation in decision-making, domestic violence, and financial control vary significantly across regions and cultures (Pukayastha et al., 2003).

Persistent and widespread gender disparities in productivity and earnings continue to define both labor markets and entrepreneurial landscapes. Women-owned businesses generate 6% to 35% less value added per worker compared to those owned by men. Similarly, female-managed farms are between 20% and 80% less productive than those managed by men, and employed women, on average, earn 20% to 80% less than their male counterparts, depending on the country.

These disparities do not reflect innate differences in capabilities between men and women as entrepreneurs, farmers, or wage earners. Instead, they largely stem from structural barriers such as smaller business or farm sizes, sectoral segregation, unequal access to education and healthcare (human capital), and differing returns on that capital. A broad array of policies and programs can

help reduce these gender gaps, ranging from legal reforms that strengthen women's economic rights to initiatives that improve access to quality childcare and promote financial literacy.

This paper centers on the economic empowerment of girls and young women, offering a model for economic empowerment as a foundation for advancing efforts to enhance employment and self-employment opportunities for this group.

2. Factors of Economic Empowerment

2.1. Individual Factors: Rising Entrepreneurial Interest Among Young Women

A key driver of young women's economic empowerment is their growing interest and active engagement in entrepreneurship. This trend reflects not only shifting economic landscapes but also evolving aspirations among young women globally.

In Pakistan, entrepreneurial ambition is notably high. According to Next Generation data, 92% of urban young women (ages 15–24) and 73% of their rural peers feel confident about starting a business. Among those aged 25–35, 91% in urban and 70% in rural areas express the same (Khan et al., 2024). Interviews conducted in 2023 support these findings, highlighting changing attitudes toward entrepreneurship, partly due to the flexibility it offers in the face of labor market discrimination.

Similarly, in Indonesia, 57% of young women (15–24) across both urban and rural areas show interest in launching businesses. The figure rises to 66% in urban and 67% in rural areas for women aged 25–35 (Khan et al., 2024). This interest is driven both by ambition and necessity, as entrepreneurship offers a practical response to a competitive and limited job market (Allison et al., 2022).

In Vietnam, 81% of urban and 68% of rural women aged 15–24 feel prepared for entrepreneurship. Interestingly, among women aged 25–35, rural readiness surpasses urban (79% vs. 75%) (Khan et al., 2024). Here, motivation often stems from a desire for autonomy and self-determination, prompting many to save and gather resources in anticipation of starting a business (Lamphere-Englund et al., 2020).

Across these contexts, young women not only view entrepreneurship as a viable career path but are also taking concrete steps toward it. Their motivations are shaped by both push factors—limited employment opportunities, systemic discrimination—and pull factors such as flexibility, independence, and economic agency. This entrepreneurial shift is a powerful catalyst for economic empowerment at the individual level.

2.2. Interpersonal Factors: Family Support

Support from close family members—particularly spouses, parents, and other household members—is a crucial interpersonal factor in the economic empow-

erment of girls and young women. This support forms a foundation that nurtures aspirations and provides emotional, logistical, and sometimes financial assistance for education, employment, and entrepreneurship.

Families often shape young women's opportunities and confidence. Key informants note that encouragement from fathers and husbands can significantly impact women's ability to pursue higher education, meaningful employment, and balance professional goals with household responsibilities. This support frequently goes beyond words, involving the shared burden of caregiving and domestic work—an essential factor for sustaining women's careers over time (Khan et al., 2024).

Though not yet widespread, examples from Indonesia and Vietnam show that when male partners are equitable, empathetic, and supportive, they enhance women's capacity to work and advance professionally. Men who actively share childcare, eldercare, and housework responsibilities help reduce the time and energy constraints that often limit women's participation in the labor force (Khan et al., 2024). These examples point to a gradual cultural shift toward more egalitarian gender roles in some families.

Early exposure to a supportive family environment also has lasting effects. Women who grow up in households that value autonomy and ambition are more likely to pursue diverse careers and enter non-traditional sectors (Khan et al., 2024). This foundation equips them to make informed life choices, including around career development, marriage timing, and family planning (Khan et al., 2024).

Household relationships form a vital layer of support that can either facilitate or hinder women's economic participation. While structural barriers persist, the presence of active and practical family support—especially from male family members—can be a decisive factor in enabling girls and young women to thrive economically.

2.3. Organizational Factors: Access to Higher Education

Access to higher education is a powerful organizational factor in the economic empowerment of young women, significantly shaping both employment prospects and broader life outcomes. It equips women with advanced knowledge, critical thinking skills, and formal qualifications, enabling them to pursue more meaningful, better-paying, and personally fulfilling careers.

Higher education plays a key role in aligning young women's aspirations with actual employment outcomes. In Vietnam, for example, 59% of women aged 15–24 with a university degree reported that their first job was directly related to their field of study—compared to just 13% among those with only a secondary education (Khan et al., 2024). This pattern holds for women aged 25–35 as well, showing long-term benefits beyond initial employment (Khan et al., 2024).

This impact extends beyond Vietnam. In Poland, higher education correlates with more positive attitudes toward work. University-educated individuals often

see their careers as part of personal identity and fulfillment, not just economic necessity (Raven et al., 2021). Education in this context helps shape values and aspirations, reinforcing the importance of meaningful work.

Insights from Pakistan, Indonesia, Vietnam, and Ethiopia further highlight the transformative role of higher education. Women with tertiary education are more likely to secure better jobs, especially in formal or professional sectors that offer stability and career growth (Khan et al., 2024). The benefits go beyond employment—higher education also enables informed, autonomous decisions about marriage, family planning, and balancing personal and professional goals.

Additionally, education fosters a stronger sense of independence and self-advocacy. Educated women are often better prepared to defend their rights, challenge discrimination, and navigate complex institutions—skills essential not only for personal empowerment but also for broader societal change (Khan et al., 2024).

Access to higher education serves as a foundational organizational factor in empowering girls and young women. It provides vital qualifications, nurtures personal development and life skills, and enhances their ability to participate meaningfully in both the economy and society.

2.4. Organizational Factors: Tech and Innovation Hubs Supporting Women's Entrepreneurship

Technology and innovation centers are emerging as powerful organizational drivers of economic empowerment, particularly for young women. These hubs not only foster entrepreneurship but also help address systemic barriers by providing essential resources and promoting inclusive participation in the digital economy.

In Pakistan, tech incubators play a pivotal role in bridging longstanding gaps for youth-led enterprises. As Babar et al. (2023) note, these centers serve as collaborative learning spaces where young entrepreneurs—especially women—build supportive networks, exchange knowledge, and challenge traditional gender norms. For women facing mobility restrictions or resistance to formal employment, access to digital tools and e-commerce platforms enables economic engagement from home, helping them bypass spatial and cultural constraints (Babar et al., 2023).

In Nigeria, the innovation ecosystem is thriving, with at least 85 active hubs, making it the most vibrant in Africa (Briter Bridges, 2019; Curran et al., 2020). These centers offer vital early-stage support—such as skill-building, mentoring, business incubation, and co-working spaces—while also serving as networking hubs that enhance women's visibility, credibility, and access to growth resources.

Beyond business, innovation hubs in Nigeria also facilitate social change. For instance, the Market March Movement, led by women to confront sexual har-

assment, highlights how these spaces empower collective advocacy and address deep-rooted gender inequalities (Curran et al., 2020).

Across Africa, key informants emphasize that these centers actively support the creative economy by nurturing innovation and entrepreneurial mindsets (Khan et al., 2024). A notable example is Nigeria's Co-Creation Hub, whose "Women in Business" program prepares female entrepreneurs to secure investment and sustainably scale their ventures. Such initiatives offer tailored support to overcome gender-specific challenges, strengthening women's financial literacy, leadership, and market access (Khan et al., 2024).

Tech and innovation hubs represent a new frontier for economic empowerment. By combining infrastructure, mentorship, digital access, and social capital, they cultivate inclusive ecosystems where young women can innovate, lead, and reshape their economic futures.

2.5. Organizational Factors: Institutions Addressing Young Women's Economic Needs

Organizations specifically designed to address the economic needs of girls and young women serve as powerful enablers of empowerment. Whether community-based, cooperative, or civil society-led, these institutions provide women with platforms to access resources, express concerns, and collectively challenge systemic barriers to economic participation.

In Sri Lanka, women-led business consortia have been welcomed by local communities. According to Khan et al. (2024), these collectives function through collaborative governance, enabling women to make joint decisions about their economic futures. These spaces facilitate engagement on critical issues such as regulatory barriers, access to finance, corruption, and institutional constraints. Beyond practical support, they also act as platforms for collective bargaining and advocacy, allowing women to amplify their voices and assert their rights more effectively (Khan et al., 2024).

In Ethiopia, women-focused Savings and Credit Cooperatives (SACCOs) are vital support structures, especially for youth aged 15–29. Operating in both urban and rural areas, these member-owned institutions are grounded in gender equality and ensure equal access and representation for women. To further support participation, SACCOs offer lower interest rates and tailored training and mentorship programs to enhance women's financial literacy and entrepreneurial skills. They serve as lifelines for young women in underserved regions, providing access to credit, savings mechanisms, and a sense of community support (Khan et al., 2024).

In Poland, the economic displacement of Ukrainian refugee and asylum-seeking women has led to the formation of civil society organizations aimed at preventing the devaluation of their professional qualifications. Many of these women were highly educated and employed prior to displacement, yet still face economic integration challenges after two years in Poland. These organiza-

tions help bridge that gap by providing targeted support services—facilitating labor market reintegration, navigating bureaucracy, and maintaining economic dignity in a foreign environment (Khan et al., 2024).

Across these diverse contexts, a unifying insight emerges: when institutions are purposefully structured to meet the specific economic needs of girls and young women, they unlock transformative opportunities. These organizations do more than provide financial tools—they foster leadership, solidarity, and collective agency, enabling young women to claim their rights and shape their economic realities.

2.6. Organizational Factors: The Rise of Inter-Organizational Collaboration

Increasing inter-organizational collaboration—particularly among governments, civil society, international organizations, and the private sector—is reshaping the landscape of economic empowerment for girls and young women. These multi-stakeholder partnerships combine resources, expertise, and reach to implement inclusive, scalable, and context-sensitive programs that support women's economic participation.

Across Pakistan, Indonesia, Vietnam, Nigeria, and Ethiopia, key informants report a growing trend of cross-sector collaboration aimed at addressing persistent gender-based economic inequalities (Khan et al., 2024). These alliances play a critical role in extending the impact and accessibility of initiatives targeting women and girls, especially in marginalized or underserved communities.

In Pakistan, a notable example is the Women's Initiative for Social Entrepreneurship (WISE), a public-private partnership launched in 2023 between the United Nations Development Programme (UNDP) and Jazz, the country's largest digital operator (Khan et al., 2024; UNDP, 2023). WISE demonstrates the potential of such collaborations to advance women's leadership in social innovation. Through intensive training camps, the program aims to equip 400 female social entrepreneurs across 12 cities with business acumen, entrepreneurial skills, and digital literacy to build sustainable, socially impactful ventures. Beyond individual capacity-building, WISE fosters a culture of social entrepreneurship that uses innovation to solve community challenges.

In Nigeria, respondents highlighted successful partnerships between government bodies—such as the Federal Ministry of Women Affairs—and civil society organizations. These partnerships aim to create a more inclusive policy environment, enhance service delivery, and strengthen institutional capacities to address the socio-economic needs of women (Khan et al., 2024). Civil society insights inform public policymaking, while government backing helps scale effective initiatives and ensures their long-term sustainability.

In Ethiopia, an inspiring example of inclusive collaboration centers on the rights and economic empowerment of women and girls with disabilities. A coalition of civil society organizations—including disability rights advocates, women's groups, and human rights organizations—works closely with the Ethiopian Women with Disabilities National Association (EWDNA) to improve access

to education, skills development, and employment (Khan et al., 2024). These efforts go beyond technical skills development, focusing also on building self-confidence and self-worth, thus enabling women with disabilities to participate more fully in economic and social life. This approach underscores the growing recognition of intersectional identities and the need for coordinated, inclusive responses.

Overall, the expansion of inter-organizational cooperation reflects a promising shift toward more integrated, cross-sector strategies in the field of economic empowerment for girls and young women. By combining technical expertise, institutional power, local knowledge, and private-sector innovation, these partnerships create more holistic and sustainable pathways for young women to access education, employment, entrepreneurship, and leadership opportunities.

2.7. Community Factors: Women as Community Role Models

Empowered women who visibly lead and challenge social norms serve as powerful catalysts for economic strength at the community level. These role models inspire others and actively open pathways for economic participation, especially for young women and girls in marginalized areas. By turning personal struggles into platforms for change, they create a ripple effect that fosters ambition, confidence, and opportunities within their communities.

In Pakistan, key informants highlighted pioneering women who transformed challenges into opportunities by founding influential organizations that drive women's empowerment (Khan et al., 2024). Notable examples include the founder of the Kashf Foundation, which provides microfinance and economic support to low-income women, and the creator of the Women's Digital League (WDL)—one of the country's first platforms offering digital training and remote work for women. These initiatives impact not only women's economic status but also expand what is possible for women in traditional or restrictive contexts.

Also in Pakistan, the founder of Baithak – Challenging Taboos, a youth- and women-led initiative, exemplifies how local leadership can break cultural silences and promote dialogue on sensitive issues, effectively reaching marginalized women and highlighting the power of peer leadership in driving social change (Khan et al., 2024).

In Indonesia, role models span government, media, academia, and business, showing young women that leadership and success are attainable. Informants emphasized the influence of high-profile female ministers, celebrities, and entrepreneurs whose public visibility shifts perceptions of women's roles and abilities (Khan et al., 2024). Importantly, everyday women with extraordinary stories, especially from rural or disadvantaged backgrounds, also have significant impact.

A compelling example is Resa Boenard, a community leader from near Southeast Asia's large Bantar Gebang landfill. Despite her challenging upbringing, she founded Kingdom BGBJ, a nonprofit providing education and scholarships to

waste pickers' children, and launched a startup converting waste into marketable products. Her story illustrates how resilience and community dedication can transform entire opportunity ecosystems (Khan et al., 2024).

Across studied countries, key informants consistently stressed the importance of personal storytelling in shaping economic empowerment pathways. These narratives of persistence and innovation inspire, validate, and offer practical guidance for other women and girls, demonstrating that empowerment is achievable even where formal support is lacking.

Ultimately, women who lead by example—whether nationally recognized figures or local champions—play a vital role in transforming mindsets and creating ambitious pathways for others. By challenging stereotypes, opening doors, and investing actively in their communities, they anchor collective progress and economic resilience.

2.8. Policy and Legal Incentives: Supporting Entrepreneurship

Supportive government policies and legal frameworks are crucial for enabling young people—especially girls and young women—to pursue entrepreneurship as a sustainable and empowering economic path. Across all seven studied countries, national and local governments have taken steps to foster more inclusive entrepreneurial environments (Khan et al., 2024). These efforts include simplifying business registration, offering financial incentives, and integrating entrepreneurship education into formal learning systems.

In Indonesia, a strategic multisectoral government approach targets building a robust entrepreneurial ecosystem by promoting entrepreneurial culture, skills training, and financing mechanisms—key factors enabling women to start and sustain businesses. Collaboration among several ministries, including BAPPENAS, MENPORA, MENKO PMK, and KEMENDAGRI, supported by international partners like UNDP, enhances this initiative by combining global best practices with local priorities (Khan et al., 2024).

In Nigeria, legal and regulatory reforms have markedly improved the entrepreneurial climate, as reflected by Nigeria's 15-place rise in the World Bank's Ease of Doing Business index (Curran et al., 2020). Reforms such as the 2020 Companies and Allied Matters Act address longstanding barriers like bureaucratic hurdles and unclear registration processes. These changes are especially valuable for women entrepreneurs, many operating informally, by facilitating formalization, financing, and sustainable growth.

Ethiopia has also advanced youth entrepreneurship with a focus on women through initiatives like the Micro and Small Enterprise Development Policy and the Youth Revolving Fund (De Schryver et al., 2019). These programs provide startup capital, technical support, and business development assistance, especially in rural and underserved areas where young women face structural barriers to credit and markets.

Overall, while policy success varies by country, a growing trend reflects increas-

ing government recognition of entrepreneurship as a route to youth empowerment, economic resilience, and gender equality. By addressing legal, institutional, and financial obstacles, these efforts help build ecosystems where young women can pursue entrepreneurial ambitions on a more equal footing—with the tools, resources, and institutional support needed to succeed.

2.9. Cross-Sectoral Factors: The Digital Economy

The digital economy is rapidly emerging as a powerful cross-sectoral driver of youth employment, innovation, and entrepreneurship. In all seven studied countries, the digital space creates alternative economic opportunities that overcome many traditional barriers to employment and business ownership—especially for young women (Khan et al., 2024). Offering flexible, affordable, and often low-entry platforms, the digital economy facilitates participation in freelancing, e-commerce, and online services. It also fosters a generation that is more creative, resilient, and independent in pursuing economic independence.

In Pakistan, 70% of youth believe the internet will become a main source of jobs, and 59% see online freelancing as a viable career (Babar et al., 2023). The digital space allows women to balance work with cultural expectations and domestic duties. Moreover, 68% of Pakistani youth think the internet opens new economic opportunities for women, with 62% highlighting e-commerce's role in female empowerment (Khan et al., 2024). However, support is lower (39%) among youth from religious education backgrounds, revealing ongoing cultural tensions (Khan et al., 2024).

In Indonesia, urban youth strategically use digital platforms like social media for income generation, bypassing saturated traditional job markets (Allison et al., 2022). Activities such as live streaming, online sales, and micro-influencer marketing are common economic pursuits. Women entrepreneurs increasingly leverage platforms like Instagram, Facebook, and LinkedIn to showcase their businesses, engage customers, and grow their influence (Khan et al., 2024).

Similarly, in Vietnam, there is strong momentum around digital startups and remote work, especially among young entrepreneurs. E-commerce platforms and online service apps simplify business and customer engagement. About 57% of Vietnamese youth use the internet, and 51% use social media for employment and educational resources (Khan et al., 2024; Lamphere-Englund et al., 2020), reflecting growing trust in digital tools for personal advancement.

In Nigeria, the digital economy surged during COVID-19 as many youths turned to online business models for survival. E-commerce and digital services became vital, particularly in urban areas (Curran et al., 2020). Yet digital inclusion remains uneven; while urban women with tech access quickly adopted digital platforms, rural women with limited digital literacy remain marginalized. In response, organizations have integrated digital literacy and e-commerce training to promote equitable access (Khan et al., 2024).

The digital economy is reshaping not only how young people work but also where, when, and with whom. By reducing structural barriers, enabling flexible

entrepreneurship, and fostering digital skills, it is a key factor in youth economic empowerment, gender equality, and innovation. Addressing digital divides based on gender, geography, and education is essential to ensure inclusive and widespread benefits from this evolving economic frontier.

2.10. Access to Capital: Loans and Grants

Experimental evidence shows that small capital injections—whether microloans or unconditional cash grants—generally fail to stimulate growth or profitability in women-owned subsistence businesses (Buvinić & Furst-Nichols, 2016). These microenterprises, earning about $80–100 monthly and roughly $1 daily profit without paid staff, see little benefit from financial interventions averaging $100–200.

This pattern holds across multiple countries. In Sri Lanka, cash grants did not increase profits for women-led businesses (de Mel, McKenzie & Woodruff, 2008, 2009, 2012). Similarly, microcredit programs in India, Bosnia and Herzegovina, Mongolia, the Philippines, and Thailand showed no improvement for poor women entrepreneurs (Duflo et al., 2013; Augsburg et al., 2012; Attanasio et al., 2011; Karlan & Zinman, 2010; Coleman, 2006). In contrast, male-owned microenterprises in Sri Lanka and the Philippines responded positively, with gains lasting up to five years in Sri Lanka (de Mel, McKenzie & Woodruff, 2012; Karlan & Appel, 2011).

Gender differences may reflect structural and behavioral factors. Women's businesses often operate in low-growth sectors and face additional demands limiting reinvestment. Women also face internal and external pressures to divert business funds to household or social needs and are often "necessity entrepreneurs," relying on self-employment due to scarce paid work options (Duvendack et al., 2011). Time constraints and restrictive social norms further limit business scale and financial capital effectiveness (de Mel, McKenzie & Woodruff, 2012).

Behavioral factors matter too. Women tend to exhibit present bias, favoring immediate consumption over future investment, while men show more future orientation (Fafchamps et al., 2014). In Uganda, young women displayed stronger present bias but still increased earnings after receiving a substantial subsidy (Blattman, Fiala & Martinez, 2014).

Evidence also supports "social taxes" or family obligations that disproportionately affect women. In Kenya, women invested less in business when income was visible to relatives, a pattern not seen in men (Jakiela & Ozier, 2012). Similar external pressures reduce women's reinvestment in Uganda and influence financial behaviors in Chile and Kenya (Fiala, 2014; Kast & Pomeranz, 2014; Schaner, 2014).

Technological solutions like mobile money show promise. In Niger, poor women receiving mobile cash transfers were more likely to invest productively due to privacy and autonomy, achieving positive agricultural outcomes (Aker et al., 2011).

In-kind transfers (e.g., livestock or supplies) also prove effective for more established women microentrepreneurs. In urban Ghana, women receiving in-kind capital experienced sustainable profit increases, likely due to fostering long-term investment mindsets and reducing immediate consumption diversion (Fafchamps et al., 2014).

For women running larger, more formal SMEs (5–19 employees), access to finance may sufficiently spur growth and income. Though gender-disaggregated evaluations remain limited, capital constraints significantly restrict firm size and profitability in women-led SMEs, contributing to persistent size gaps with male-owned firms (Klapper & Parker, 2011; Sabarwal & Terrell, 2008). Financial barriers broadly hinder SME growth in developing countries regardless of owner gender (Ayyagari, Demirguc-Kunt & Maksimovic, 2012).

Among youth, large unconditional cash grants can have strong, lasting effects—especially for young women. A randomized trial in conflict-affected northern Uganda found significant income gains lasting four years after grants were given without additional training, with larger effects for women starting from a lower economic base (Blattman, Fiala & Martinez, 2014). Such transfers, if sufficiently large and given time to mature, may similarly benefit adult women running subsistence businesses by helping overcome capital constraints.

Timing also shapes financial intervention outcomes. Longitudinal data from Bangladesh show that cumulative microcredit access positively impacted household income and reduced extreme poverty, with stronger gains among female borrowers (Khandker & Samad, 2014). Prior credit experience may encourage greater risk-taking and investment over time, particularly relevant for women who often have higher risk aversion.

Supporting this, a study in Kolkata, India, found that offering a two-month grace period before loan repayment led to significantly higher business profits three years later among poor female urban borrowers. This extra time enabled greater risk-taking and more productive investments (Field et al., 2014). These findings highlight how financial product design—not just access—critically influences women's willingness and ability to take calculated business risks.

2.11. Business Training

Business management training programs, often offered by microfinance institutions and banks, vary widely in duration, quality, and scope, making it difficult to assess their overall effectiveness. A systematic review by Woodruff and McKenzie (2013), analyzing 20 evaluations involving female trainees, alongside a complementary review by Bandiera et al. (2013a) on combined training and capital transfer interventions, finds that while training generally improves business practices among women micro-entrepreneurs, it rarely leads to significant gains in business survival or profits. This trend appears across multiple countries, including Bosnia and Herzegovina (Augsburg et al., 2012), Pakistan (Gine & Mansuri, 2014), Peru (Valdivia, 2011), Sri Lanka (de Mel, McKenzie & Woodruff, 2012), and Tanzania (Oppedal Berge, Bjorvatn & Tungodden, 2011).

Limited positive outcomes are more consistently observed among women due to their engagement in lower-quality jobs and greater external constraints, such as heavier household responsibilities and limited influence on domestic decisions (Gine & Mansuri, 2014; Oppedal Berge et al., 2011). Women also tend to drop out of training programs more frequently than men, indicating many programs inadequately address the specific barriers faced by women entrepreneurs (Valdivia, 2013; Woodruff & McKenzie, 2013).

Training seems more effective in boosting income and profit for newly established businesses. For example, in Sri Lanka, training helped women previously outside the workforce start businesses faster, though fostering growth after startup remained challenging (de Mel, McKenzie & Woodruff, 2014). Additionally, training correlates with improved microloan repayment rates, suggesting indirect financial benefits (Woodruff & McKenzie, 2013).

Woodruff and McKenzie (2013) argue that high-quality training yields better returns for larger firms, where even modest profit increases justify training costs, as these costs scale subproportionally with firm size. Similarly, Xu and Zia (2012) find training more effective for women-owned small and medium enterprises (SMEs) than microenterprises and recommend targeting motivated, self-selected women entrepreneurs to maximize impact.

Short courses lasting two to three days are common but likely less impactful than longer, intensive programs. For instance, a six-week, fully subsidized, high-quality basic business education program for poor rural women micro-entrepreneurs in Mexico significantly improved accounting practices (Calderon, Cunha & de Giorgi, 2013). Likewise, a three-month intensive training led by specialists increased sales among women micro-entrepreneurs in Peru. While only combined training and tailored technical assistance initially boosted sales, women receiving training alone caught up after about two years by adopting recommended practices and adjusting their businesses—albeit more gradually. Notably, training was cost-effective, unlike tailored technical assistance, which was twice as expensive and whose positive effects faded by the second year (Valdivia, 2011, 2013).

2.12. Capital Plus Training

Combining capital transfers with targeted training shows strong potential—especially for ultra-poor women—when well-designed and sustained over time (Buvinić and Furst-Nichols, 2016). In a major Bangladeshi program, Bandiera et al. (2013a) provided extremely poor women with productive assets, specialized asset-related training, and ongoing mentorship via regular visits over two years. This led to transformative outcomes: women shifted from unstable low-paid daily labor to self-employment with significant, lasting income gains, visible even four years after the program ended (Bandiera et al., 2013b). Those with higher initial incomes experienced the greatest improvements, highlighting baseline conditions' importance.

Similar "graduation-style" pilots in West Bengal and Andhra Pradesh, India, confirmed positive impacts (Banerjee et al., 2011; Morduch, Ravi, and Bauchet,

2012; Bandiera et al., 2013a). However, concurrent government employment programs in Andhra Pradesh complicated attribution. Still, consistent results across contexts strengthen the case for integrated capital-plus-training programs targeting the ultra-poor. Bandiera et al. (2013a) found these resource-intensive interventions yielded better returns than comparable savings account investments, based on five cost-tracking studies.

Yet, capital-plus-training success varies. In Sri Lanka and Uganda, similar interventions combining business training with one-time capital transfers produced mixed results. In urban Sri Lanka, a $130 grant plus training initially boosted women microentrepreneurs' earnings, but gains faded within two years (de Mel, McKenzie, and Woodruff, 2014). In semi-urban Uganda, a roughly $200 capital-plus-training intervention raised profits for male entrepreneurs but not women. Men translated short-term gains into lasting profits thanks to training, while women did not. A key barrier was household financial pressure: married women often had to share resources with family, undermining reinvestment. In contrast, married men leveraged family ties by employing relatives. Notably, women living apart from their families benefited from the program, suggesting that reducing social and family constraints can improve outcomes for women (Fiala, 2014).

3. Model of Economic Empowerment of Girls and Young Women

To develop a theoretical model of economic empowerment for girls and young women, this framework integrates Bronfenbrenner's socio-ecological model with additional layers specific to economic empowerment, such as access to capital and business training. Drawing on insights from the Next Generation reports (Khan et al., 2024), which included qualitative interviews, the model explores and analyzes the multi-dimensional factors that shape the economic empowerment of young women. These factors are organized across several levels (see Figure 1):

- **Individual Level**

  At the center of the model is the individual woman, whose personal characteristics influence her economic capacity and ambitions. These include:

  - *Demographics*: Age, marital status, and number of dependents.
  - *Human Capital*: Educational attainment, vocational training, and work experience.
  - *Psychological Factors*: Self-efficacy, confidence, risk tolerance, motivation, and entrepreneurial mindset.
  - *Health and Well-being*: Both physical and mental health significantly impact the ability to work or engage in entrepreneurial activities.

  Empowerment implications: Women with higher education, digital literacy, and self-confidence are more likely to access economic opportunities and overcome structural barriers.

- **Interpersonal Level**

  This level emphasizes immediate social networks, such as:

  - *Family and Household Dynamics*: Support or resistance from spouses and/or parents.
  - *Social Networks*: Influence of friends or peers, especially other women, who may encourage or discourage economic engagement.
  - *Mentorship and Role Models*: Exposure to successful female entrepreneurs or professionals who offer guidance.

  Empowerment implications: Social support is crucial. For instance, women with supportive partners are more likely to seek employment or launch businesses.

- **Organizational / Community Level**

  This level covers institutions and community environments that influence women's opportunities:

  - *Schools and Training Centers*: Access to skills and professional development.
  - *Employers and Labor Markets*: Workplace policies on maternity leave, pay equity, and safety.
  - *Community Norms and Safety*: Issues such as gender-based violence, restricted mobility, and acceptance of women in leadership roles.

  Empowerment implications: Women thrive economically in inclusive, safe, and gender-sensitive institutions.

- **Societal Level**

  This layer reflects entrenched social and cultural norms, including:

  - *Patriarchal Values*: The belief that men should be breadwinners and women caretakers.
  - *Gender Stereotypes*: Perceptions of which jobs are "appropriate" for women.
  - *Media Narratives*: Representation of women as competent and autonomous economic actors.

  Empowerment implications: Shifting societal attitudes about gender roles is essential for normalizing women's economic participation.

- **Policy and Legal Level**

  This level refers to the political environment and legal structures that either enable or hinder women's economic activities:

  - *Labor Laws*: Minimum wage, maternity rights, and anti-discrimination protections.
  - *Property and Inheritance Rights*: Women's ability to own or inherit land and assets.
  - *Education and Skills Policies*: Investment in vocational training targeting women.
  - *Entrepreneurship and SME Policies*: Government support for women-owned businesses.

  Empowerment implications: Enabling policies enhance women's access to employment, entrepreneurship, and financial independence.

- **Access to Capital**

  This dimension acknowledges that financial resources are central to economic empowerment:

  - *Microcredit and Grants*: Specifically targeted at women entrepreneurs.
  - *Creditworthiness and Collateral Access*: Gender disparities in financial access.
  - *Digital Financial Services*: Mobile banking, e-wallets, and fintech platforms tailored to women's needs.

  Empowerment implications: Women's ability to access and control financial resources directly affects their autonomy and potential to launch or grow a business.

- **Business Training**

  This layer encompasses the skills and competencies required for participation in both the formal and informal economy:

  - *Entrepreneurship Training*: Business planning, marketing, and financial literacy.
  - *Digital Skills*: E-commerce, online marketing, and platform usage.
  - *Mentorship Programs*: Long-term guidance and leadership development.

  Empowerment implications: Business training not only boosts women's income-generating potential but also builds confidence and leadership capacity.

The model assumes that the economic empowerment of girls and young women is a multi-layered, interconnected process. Change at any level (e.g. access to capital) is influenced by and can affect other levels (e.g. interpersonal support or the political environment). Therefore, successful interventions must be holistic and context-specific, addressing barriers and enablers at all levels. This model provides a comprehensive framework for understanding and fostering the economic empowerment of girls and young women.

Women in developing countries face a dynamic set of opportunities and obstacles on their path to economic empowerment. While factors such as entrepreneurship support, digital access, and skills training offer pathways to prosperity, numerous interpersonal, organizational, social, and political barriers continue to undermine progress.

The economic empowerment of girls and young women requires a holistic and intersectoral policy approach. As digital and entrepreneurial opportunities grow, they must be aligned with structural reforms that eliminate gender biases, increase the coherence of education and work, and improve access to public services. Governments, in partnership with NGOs and the private sector, must act decisively to ensure the economic empowerment of girls and young women.

The Girls and Young Women Economic Empowerment Model provides a framework for municipalities to shape the direction of their strategies for the economic empowerment of girls and young women, particularly within the factors

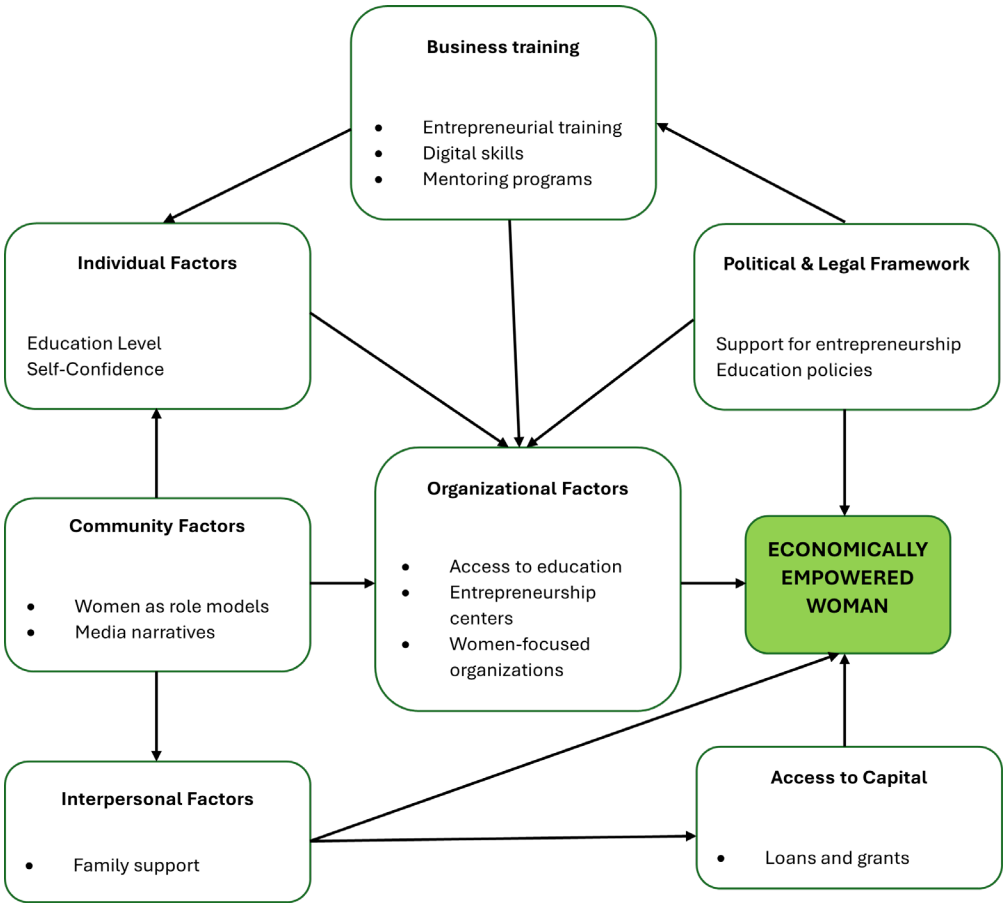


Figure 1. Model of economic empowerment of girls and young women

Source: Authors creation

that are within the control of their institutions, such as organizational factors, access to capital, and business training, as well as influencing the appropriate policy and legal framework.

4. Conclusion

Girls and young women in Bosnia and Herzegovina face numerous obstacles in accessing education, the labor market, and economic opportunities. The economic inactivity of this population, especially in rural and socioeconomically marginalized areas, represents a significant challenge for the development of an inclusive and sustainable economy. High unemployment rates, limited access to financing sources, and outdated educational programs that are not aligned with market needs further worsen the position of girls and young women in society. In order to improve their position and enable economic independ-

ence, it is necessary to create a functional model of economic empowerment that combines educational, psychosocial, financial, and institutional measures.

The first step towards empowerment is education. It is necessary to organize comprehensive education on business idea development, the basics of entrepreneurship, financial management, digital literacy, and working in a modern digital environment. Special focus should be placed on the availability of this education to girls in remote and less developed areas, through online formats and local educational centers. In parallel, it is important to implement programs that offer psychological support and strengthen the self-confidence of young women through group workshops and individual counseling, as a sense of self-worth and motivation play a key role in entrepreneurial activity.

Quality vocational training in line with labor market requirements is another key component of this model. Programs should be flexible and targeted at shortage occupations, with an emphasis on supporting marginalized groups, including young women with no prior work experience. It is also necessary to develop sustainable financial support mechanisms, including grants for the best business ideas of young women. Allocated funds should be monitored through mentoring programs and impact evaluation of newly launched businesses, to ensure their long-term sustainability and social contribution.

Institutional support must include simplified business registration procedures, digitalization of processes, and increased availability of credit lines and microfinance for women's entrepreneurship. In parallel, it is necessary to establish business start-up counseling centers that will provide legal, administrative, and advisory services to girls and young women. The active role of employment agencies is also crucial – through the development of educational programs, networking with the private sector and introducing a voucher system for training and internships.

To ensure the quality and long-term impact of all the above measures, it is crucial to establish a system of regular monitoring and evaluation, which will track the performance of the programs through clear gender-sensitive indicators. Cooperation between local authorities, the non-governmental sector and international partners is necessary to ensure the sustainability of entrepreneurial initiatives at the local level. In addition, networking with international organizations in the areas of mentoring, financing and training can bring additional resources and experience in strengthening the capacities of domestic actors.

Finally, the promotion of internship and employment programs must be a strategic priority. Subsidizing work internships and stimulating employers to hire young women can significantly contribute to their inclusion in the formal labor market. By integrating the above measures and approaches, it is possible to create an environment that enables girls and young women to develop their full potential, achieve economic independence and actively contribute to community development. It is time to move from strategies and plans to concrete actions that change the lives of girls and young women in Bosnia and Herzegovina.

References

1. Augsburg, B., R. de Haas, H. Harmgart, and C. Meghir. (2012). Microfinance, Poverty and Education. Working Paper 18538. National Bureau of Economic Research, Cambridge, MA.
2. Bandiera, O., R. Burgess, N. Das, S. Gulesci, I. Rasul, and M. Sulaiman. (2013b). Can Basic Entrepreneurship Transform the Economic Lives of the Poor? IZA Discussion Papers 7386. Institute for the Studyof Labor, Bonn, Germany.
3. Bandiera, O., R. Burgess, S. Gulesci, I. Rasul, and M. Sulaiman. (2013a). Capital, Skills and the Economic Lives of the Poor: Recent Evidence from Field Experiments. A Roadmap for Promoting Women's Economic Empowerment.
4. Banerjee, A., E. Duflo, R. Chattopadhyay, and J. Shapiro. (2011). Targeting the Hard-Core Poor: An Impact Assessment. Innovations for Poverty Action, New Haven, CT.
5. Briter Bridges (2019). 618 Active Tech Hubs in Africa: The Backbone of Africa's Tech Ecosystem. London: Briter Bridges.
6. Buvinić, M., & Furst-Nichols, R. (2016). Promoting women's economic empowerment: what works?. The World Bank Research Observer, 31(1), 59-101.
7. Calderon, G., J. Cunha, and G. de Giorgi. (2013). Business Literacy and Development: Evidence from a Randomized Controlled Trial in Rural Mexico. Working Paper 19740. National Bureau of Economic Research, Cambridge, MA.
8. Curran, T., Power, G., Symington, L., Amadi, O., Park, S., Razaq, U. (2020). Next Generation Nigeria. London: British Council.
9. de Mel, S., D. McKenzie, and C. Woodruff. (2012). One-Time Transfers of Cash or Capital have Long-Lasting Effects on Microenterprises in Sri Lanka. Science 335 (6071) : 962–6.
10. de Mel, S., D. McKenzie, and C. Woodruff. (2014). Business Training and Female Enterprise Start-Up, Growth, and Dynamics: Experimental Evidence from Sri Lanka. Journal of Development Economics 106 : 199–210.
11. De Schryver, C., Nielsen, M., Day, H., Johns, E., and Goldthorpe, J. (2019). Next Generation Ethiopia. London: British Council.
12. Fiala, N. (2014). Stimulating Microenterprise Growth: Results from a Loans, Grants and Training Experiment in Uganda. Working Paper. German Institute for Economic Research, Berlin, Germany.
13. Gine, X., and G. Mansuri. (2014). Money or Ideas? A Field Experiment on Constraints to Entrepreneurship in Rural Pakistan. Policy Research Working Paper 6959. World Bank, Policy Research Department, Washington, DC.
14. Khan, A., Khan, F., Raineri, S., & Khurram, S. (2024). Next Generation: What We Know on Women and Girls. British Council. doi.org/10.57884/9FR8-5T03.
15. Morduch, J., S. Ravi, and J. Bauchet. (2012). Failure vs. Displacement: Whyan Innovative Anti-Poverty Program Showed No Net Impact. Discussion Paper Series 32. PRIMCED, Tokyo, Japan.
16. Oppedal Berge, L., K. Bjorvatn, and B. Tungodden. (2011). Human and Financial Capital for Microenterprise Development: Evidence from a Field and Lab Experiment. CMI Working Papers 1. Chr. Michelsen Institute, Bergen, Norway.
17. Valdivia, M. (2011). Training or Technical Assistance? A Field Experiment to Learn What Works to Increase Managerial Capital for Female Microentrepreneurs. Processed. World Bank, Washington, DC.
18. Valdivia, M. (2013). Business Training Plus for Female Entrepreneurship? Evidence from a Field Experiment in Peru. GRADE Working Paper, Lima, Peru.
19. Woodruff, C., and D. McKenzie. (2013). Improving the Productivity and Earnings of Women-Owned and/or Managed Enterprises in Developing Countries: What Works? A Roadmap for Promoting Women's Economic Empowerment.
20. Xu, L., and B. Zia. (2012). Financial Literacy around the World: An Overview of the Evidence with Practical Suggestions for the Way Forward. Policy Research Working Paper 6107. World Bank, Policy Research Department, Washington, DC.

van. prof. dr. Samir Smailbegović[1]
van. prof. dr. Azra Hanić-Sućeska[2]
dr. sc. Senad Mehinović[3]

Original scientific paper

FACTORS AFFECTING THE INSURANCE - THE CONNECTION OF PERSONAL CHARACTERISTICS WITH INDIVIDUAL RISK MANAGEMENT

Abstract

Understanding the decision-making behavior in insurance through the analysis of factors influencing the insurance offers entrepreneurs multiple starting points. This paper focuses on basic personal characteristics, as well as on individual risk management factors, as well as on those factors that are relevant. As part of empirical research, data on personal characteristics, attitude towards risk, risk awareness, risk acceptance were collected and evaluated, all for the purpose of explaining the process of concluding the chosen insurance product that individuals go through. Therefore, personal characteristics such as extraversion, for example, affects the contracts for insurance against work incapacity and the conclusion of private pension insurance, as well as the number of insurances, and the awareness of the possibility of certain risks. The influence on accident insurance and legal insurance, as well as the willingness to take risks, is identified through the personal characteristic of tolerability. For the peculiarity of conscientiousness, which was also confirmed with random respondents, it can be argued that it has an influence on the legal insurance and accident insurance. These findings should serve marketing workers in insurance to understand the processes that individuals go through when concluding an insurance contract and the connection of the type of insurance with personal characteristics, for the purpose of providing adequate types of insurance to clients.

Key words: *Insurance, Personal Characteristics, Risk Management, Marketing.*

1 Fakultet za menadžment i poslovnu ekonomiju Univerziteta u Travniku, samir.smailbegovic@gmail.com
2 Fakultet za menadžment i poslovnu ekonomiju Univerziteta u Travniku, azra.hanic@bba.edu.rs
3 Fakultet za menadžment i poslovnu ekonomiju Univerziteta u Travniku

1. Introduction

Despite the importance of insurance in individual risk management, it can be observed that the population of Bosnia and Herzegovina has a very low number of concluded insurance contracts for certain insurance products—such as disability insurance, accident insurance, legal protection insurance, and private pension insurance—especially when compared to the volume of contracts for products like auto liability (auto-fol) or partial casco insurance. This indicates that insurers need to better understand client behavior in making insurance decisions, in order to more effectively offer their products through appropriate and targeted marketing. Ultimately, this should lead to an increase in insurance coverage for the insurers, and thus better business performance on the one hand, and on the other, to educate and interest the population in these types of insurance, which could help reduce uncertainties in their future lives—particularly in regard to, for example, private pension insurance.

For this purpose, it is necessary to research individual differences and the heterogeneity of insurance seekers (Grill, Lindner, Lüpertz, 2023:8). It is assumed here that many demographic characteristics have already been thoroughly studied and analyzed, as they are widely known and easily accessible (such as age, income, education, etc.). All these indicators and insights about insurance seekers are very useful for understanding the process a person goes through when entering into an insurance contract (Durkin & Elliehausen, 2018:18; Sidhardha & Sumanth, 2017:5) owever, the influence of personality traits on risk perception, in the context of entering into an insurance agreement as a consequence of that perception, has not yet been sufficiently explored.

This topic was addressed in a study by Häusler et al. in 2019, in which they investigated the relationship between personal characteristics and the conclusion of insurance contrac (Häusler & all., 2019:1).

Does personality influence the decision to conclude an insurance contract? And what role do the individual steps in personal risk management play in the decision-making process regarding insurance? The research presented below aims to answer these two questions by examining the correlations between personal traits and the conclusion of contracts, taking into account risk awareness, attitude towards risk, and risk acceptance, all of which are potential determinants being explored in the context of concluding insurance contracts.

The aim of this paper is to identify and examine the relevant determinants in the decision to conclude an insurance contract for a specific type of insurance, while taking into account the personal traits and individual risk management approach of the insurance seeker. Based on this, actionable recommendations will be derived for insurance companies, so that they can align their marketing and business organization with these influential factors in the decision-making process. This paper, through its modest contribution, also aims to help fill existing research gaps, particularly regarding the territorial limitation to our country.

2. Individual Risk Management

2.1. Definition and Distinction

To define risk management, one must first begin by defining the concept of risk itself. Based on commonly accepted opinions across various fields, risk can be considered as the possibility of adverse events occurring (Foitzik, Grünewald, 2023:28), or as "the chance of injury, damage or loss" („possibility of injury, damage or loss", Slovic, 1999:690).

Despite the omnipresence and relevance of the concept of risk, there is no consensus on a precise and universally accepted definition (Brachinger & Weber, 1997:236) . Some define risk as:

"The variation in possible outcomes of an event that is subject to chance. The greater the variation, the more risky the event is" (Thürmann, Kettler, 2019:136).

Others describe the concept of risk by assessing how risky a given alternative is, trying to quantify it through risk awareness or perception. In this case, risk is viewed as a negative attribute that characterizes a decision-making alternative and considers the possibility of injury or loss resulting from a specific action (Brachinger & Weber, 1997:235).

When looking at risk from a management perspective, it can be defined as the "maximum potential loss" (Ernst, Rogler, 2018:125). Each applied definition of risk in the literature leads to a specific approach to risk management. For the purposes of this research, general definitions have been adopted that best explain the nature of insurable risks in relation to individuals: the possibility of a negative event that leads to a loss of value upon occurrence. Therefore, the goal of all decision-makers related to insurance should be to minimize risk (Härle, Saidole, Ter Schmitten, 2023:186).

Based on this chosen definition of risk, we can further define the concept of risk management. Risk management can generally be defined as a structured management process aimed at reducing uncertainty through risk assessment (Wang & Hsu, 2009:610).

Individual risk management, as a fundamental aspect of personal financial planning—as opposed to asset management, which is governed by modern portfolio theory—has received insufficient attention in both research and literature. There is no established concept in the literature for "individual risk management"; it most often includes the identification of risk exposures and the selection of appropriate products to mitigate those risks (Finke & all., 2010:1).

This paper will therefore rely on the concept of risk management in businesses, as it serves as an example for the application of individual risk management: "All economic actors have to deal with risk and uncertainty" (Robold, Berthold, Schmitz, 2023., p. 217). Businesses and private individuals face similar risks, such as property loss or damage, legal disputes, etc.

Many empirical studies have found only minimal differences between risk assessments made by experts and those made by laypersons (Liebwein, P., 2018:341). The influence of heuristics (problem-solving strategies) on risk awareness among laypersons aligns with the risk awareness observed in experts (Slovic et.all., 2004:315).

The key difference between business and individual risk management lies in the willingness to accept risk. Businesses, due to their profit-oriented nature, are prepared to take on risks in the hope of a favorable outcome, whereas private individuals are more likely to pay higher insurance premiums in order to reduce the impact of potential risks (Finke & all., 2010:1).

2.2. Risk Identification

The risk management process is based on systematic, multi-step risk analysis structures aimed at assessing the probability and consequences of the occurrence of a particular risky event. As such, it is divided into the following parts: risk identification, risk assessment, and risk management (Kunkel, B., 2022:223).

Risk analyses typically model the impact of a negative event, such as an accident, along with its consequences for the victim, which may include death, injury, or financial loss (Slovic, 2000:283).

For a more concrete representation of the risk analysis process, this paper will draw analogies from business risk management processes, including risk analysis, risk identification, and risk assessment. Risk analysis and its evaluation, according to ISO standards (ISO 31000:2018), will be summarized under the concept of **risk assessment**, as both steps consider the probabilities and impacts of a risk (Romeike, 2018:36).

This results in a **four-step process** used in business risk management, which includes:

- Risk identification
- Risk assessment
- Risk management
- Risk monitoring (Romeike, 2018:36).

The fourth and final step in this process — **risk monitoring** — will not be investigated in this paper, as it occurs immediately after the risk management phase and, therefore, does not have an initial influence on the conclusion of an insurance contract. For the purposes of this research, it is considered irrelevant.

An ideal, typical risk management cycle based on **ISO Standard 31000:2018** is presented in Figure 1.

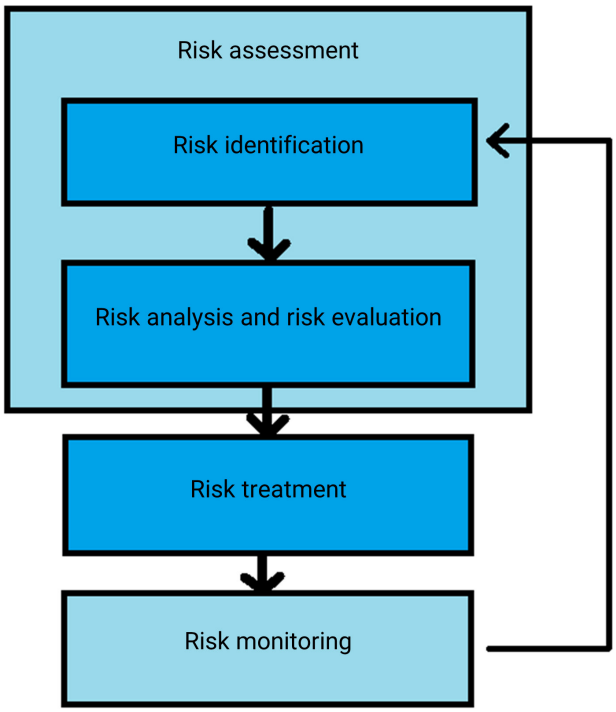


Figure 1. Risk management control loop according to ISO 31000:2018

Source: ISO/TC 262, 2018:2

3. Formulation of Research Hypotheses

The theoretical basis, especially regarding the process of individual risk management, has been explained in the previous sections of this paper and chapter. The presented influencing factors on the conclusion of insurance contracts support the assumption that personal characteristics affect the entire risk management process in individuals—through risk identification, risk assessment, and risk management. The impact of personal traits on the concept of risk attitude and risk awareness can be classified within individual risk evaluation as well as insurance uptake. Therefore, they can be seen as a key element of individual risk management—something that has already been empirically proven (Theil, 2002:28; Lauriola i Weller, 2018:8; Benischke et. all., 2019:124; Häusler et. all., 2019:8).

Based on the assumption that personal characteristics influence the individual risk management process, the following research hypotheses can be proposed:

H1: Personal characteristics have an impact on risk identification.
H2: Personal characteristics have an impact on risk assessment.
H3: Personal characteristics have an impact on risk management.

The steps of risk identification and risk assessment can be viewed as preliminary phases of risk management. Therefore, it is assumed that risk management—which ends with the conclusion of an insurance contract—is influenced by the preceding phases of risk identification and assessment. Additionally, behavior under uncertainty can be seen as a result of risk attitude and risk awareness, which can be classified under risk assessment. Based on this assumption, the following two hypotheses are defined:

H4: Risk identification has an impact on risk management.
H5: Risk assessment has an impact on risk management.

4. Construction of Research Elements

In order to construct a research instrument suitable for testing the proposed research hypotheses, it is first necessary to define the constructs of risk identification, risk assessment, risk management, and personal traits in relation to their variables.

As presented in this chapter, **risk awareness** is taken as the key element of individual risk identification. Based on this, risk awareness will be used as the measurable variable for risk identification in this research. For risk assessment, **risk attitude** and **risk acceptance** will be used as variables. The element of risk management will be captured by the variable **insurance uptake**. Insurance is the dominant instrument of risk management among individuals and the focus of this research; therefore, other instruments of risk management will not be considered.

As personal traits, the **Big Five personality dimensions** (neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness) will be included, as they consistently dominate personality trait frameworks. In addition, **ambiguity tolerance** will be considered as a personality trait, as it also strongly influences decision-making behavior under risk. The listed construct variables and the applied measurement instruments are jointly presented in Table 1.

Table 1. Overview of research variables and applied questionnaire

Construct	Variables	Applied Questionnaire
Risk Identification	Risk awareness	Self-developed item
Risk Assessment	Risk attitude Risk acceptance	SOEP Self-developed item
Risk Management	Insurance uptake	Self-developed item
Personal Characteristics	„Big Five" Ambiguity tolerance	NEO-FFI IMA, MAT-50

Source: Author's own compilation

Risk attitude represents the basic characteristic to be covered by an item from the **Socio-Economic Panel (SOEP)**. The item is based on general risk willingness across all areas of life. **Risk acceptance** will be addressed in this research through awareness of the likelihood of occurrence and the magnitude of potential harm posed by the risk.

The **NEO-FFI** includes characteristic statements in the fields of neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness through 60 items. To maintain a manageable questionnaire length, not all items will be used; instead, 6 items per dimension will be selected.

In this study, **ambiguity tolerance** will be measured using a combination of two different inventories. The **Inventory for Measuring Ambiguity Tolerance (IMA)** will include selected items from the dimensions: *tolerance/intolerance of ambiguity in unsolvable problems* and *tolerance/intolerance regarding openness to new experiences*. Additionally, the **Measure of Ambiguity Tolerance (MAT-50)** by Norton will be applied (Norton, 1975:523-525). Given that the focus of this research is on final insurance decisions, only items from the *problem-solving* section of MAT-50 will be used.

5. Quantitative Research

5.1. Implementation of the Survey

The sample consisted of 122 respondents[1], of whom 42 were male (34.4%), 71 were female (58.2%), and 9 respondents (7.4%) did not disclose their gender. The respondents were aged between 18 and 62 years, with an average age of 23, and an arithmetic mean of 26.4 years.

The sample was[2] selected based on the principle of convenience sampling. Due to this sampling method, the findings cannot be generalized to the entire population of Bosnia and Herzegovina, as the sample is not representative. However, this method was chosen to derive tendencies and examine correlations, for which purpose it is appropriate.

Based on the collected data, a value was created for each respondent for the "Big Five" dimensions, as well as for ambiguity tolerance. Additionally, the number of concluded insurance contracts was recorded for each respondent, derived from the sum of all insurance policies they had concluded.

The evaluation of the collected data was conducted based on logistic regression analysis. In this study, separate logistic regression analyses were performed for each insurance product. The dependent variables were the concluded insurance contracts, while the independent variables included personal traits, risk attitude, risk awareness, and risk acceptance, which was further divided into two subcategories: acceptance of the likelihood of risk occurrence and acceptance of potential damage.

1 All participants who provided answers to all the questions and who are independently responsible for concluding their own insurance were taken into consideration.

2 The population for this research is defined as the entire adult population of Bosnia and Herzegovina aged 18 and over. At the age of 18, individuals possess legal autonomy to enter into contracts.

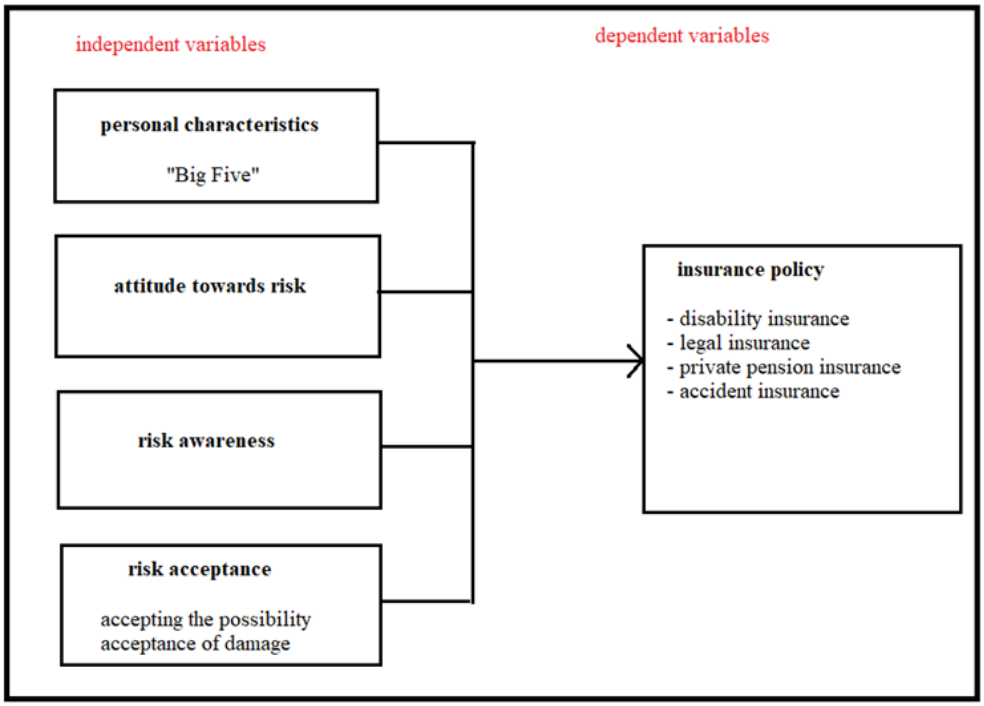


Figure 2. Logistic Regression Analysis

Source: Author's own creation

Significance values up to the level of 0.05 were treated as statistically significant in this research. Variables that did not meet this criterion were excluded from the regression analysis. Multiple regression analysis was used to simultaneously monitor several variables. Similarly to logistic regression analysis, variables that did not reach the 5% significance level were also eliminated in the multiple regression analysis.

Before proceeding with the calculation of the collected data, it was necessary to evaluate the quality of the applied measurement models.

5.2. Presentation and Discussion of Results

The results of the logistic regression analysis for each of the four selected insurance products will be presented first. After that, the results of the multiple regression analysis will be shown, with the number of concluded insurance contracts as the dependent variable. The purpose of all these results is to examine the previously stated hypotheses H3, H4, and H5. Finally, hypotheses H1 and H2 will be tested using individual multiple regression analyses, with the dependent variables being risk awareness, risk attitude, acceptance of the likelihood, and acceptance of the severity of the expected event.

For the logistic regression analysis related to the conclusion of disability insurance, the following results were obtained, as shown in Table 4. The factors influ-

encing decisions on this type of insurance include net income, the importance of extraversion, risk awareness, risk attitude, and acceptance of probability—all of which have an impact on the final decision to purchase disability insurance.

As net income increases, so does the likelihood of concluding such an insurance contract. This can be interpreted as the availability of greater financial resources associated with higher net income. A higher level of extraversion positively affects the conclusion of a disability insurance contract. Additionally, with increased risk awareness and a stronger expectation that the harmful event may occur, the likelihood of purchasing insurance also increases. This can be explained by the influence that risk awareness and risk acceptance have on behavior in the face of risk.

No significant relationship was found between the conclusion of insurance and the variables of neuroticism, extraversion, openness to experience, agreeableness, conscientiousness, age, risk attitude, and awareness of the extent of damage—due to a lack of statistical significance.

Table 2. Results of Logistic Regression Analysis for Each Insurance Product

Variable	Disability insurance	Accident insurance	Private pension	Legal insurance
Neuroticism	0,972 0,5998	1,069 0,2114	0,967 0,5473	1,093 0,1261
Extraversion	**1,202** **0,0259***	1,116 0,1329	1,193 0,0273*	1,166 0,0591**
Openness to experiences	0,951 0,329	0,987 0,7857	0,995 0,9206	0,919 0,1154
Tolerability	1,01 0,896	**0,869** **0,061****	0,987 0,8627	**0,841** **0,0402***
Conscientiousness	1,041 0,5992	**1,148** **0,0558****	0,966 0,6467	**1,264** **0,0046***
Tolerance for ambiguity	0,975 0,4499	1,026 0,3974	0,952 0,1378	1,013 0,6901
Attitude towards risk	1,162 0,3279	1,047 0,7477	1,109 0,5094	1,271 0,1433
Risk awareness	1,361 0,0416*	1,203 0,3219	0,963 0,8554	1,243 0,306
Acceptance of probability	**1,755** **0,0222***	1,182 0,4438	**1,612** **0,038***	1,164 0,5322
Acceptance of harm	1,003 0,9853	0,999 0,9969	0,797 0,2467	1,134 0,5077
Age	0,943 0,1431	1,011 0,7805	1,011 0,7813	**1,127** **0,014***
Net income (monthly)	1,665 0,0522**	1,331 0,2532	**2,472** **0,0026***	1,193 0,5006

* p<0,05, **p<0,1

For the conclusion of an accident insurance policy, a logistic regression model with a significance level of 5% could not be generated, as all independent variables exceeded this threshold. However, at a 10% significance level, a logistic regression model could be developed for concluding accident insurance, indicating the influence of **risk awareness**, **agreeableness**, and **conscientiousness**.

At a very high level, the personality trait of **agreeableness** reduces the likelihood of concluding a **legal insurance** policy. The willingness to cooperate and be accommodating, which characterizes individuals with high agreeableness, may explain this result. Such individuals tend to avoid confrontational situations rather than insist on asserting their opinions. Consequently, the utility of legal insurance is evaluated as lower among highly agreeable individuals, leading them to opt against purchasing such policies.

In contrast, individuals with pronounced **conscientiousness** are more likely to conclude a legal insurance policy. Conscientious individuals are disciplined, meticulous, orderly, and exhibit high levels of self-control (Thürmann i Kettler, 2019:12). These traits drive them to pursue legal insurance, either to maintain order and justice or to protect themselves against false accusations. Furthermore, their desire for control in legal matters—spanning areas such as work, tenancy, or family—may motivate them to take out such insurance. In addition, **older age** increases the willingness to conclude this type of insurance policy.

From the **multiple regression analysis** presented in Table 2, an increase in the significance of variables was observed.

Net income, **extraversion**, and **risk attitude** are positively correlated with the number of insurance policies concluded. An increase in net income by one unit leads to an approximate increase of **0.45** in the number of policies. An increase in extraversion by one unit leads to an approximate increase of **0.11** in the number of policies. A higher average risk awareness leads to an increase of about **0.48** insurance policies. The global measure of model fit (r) for the regression function is **0.2544**, indicating that **25.44%** of the variance in the dependent variable (number of policies) is explained by the independent variables net income, extraversion, and average risk occurrence awareness.

The research results were primarily aggregated to evaluate the proposed hypotheses. With high levels of **extraversion**, the likelihood of concluding **disability insurance**, **private pension insurance**, and the **overall number of insurance policies** increases. High levels of **agreeableness** reduce the probability of concluding **accident** and **legal insurance** policies. On the contrary, high levels of **conscientiousness** significantly increase the likelihood of concluding **accident** and **legal insurance**. Higher **risk awareness** increases the likelihood of concluding **disability** and **accident insurance**. Greater **acceptance of risk probability** leads to an increase in the likelihood of concluding **disability insurance**, **private pension insurance**, and a **general rise** in the number of concluded insurance policies. As an economic variable, **higher net income** increases the likelihood of concluding **disability and private pension insurance** and has a generally **positive effect** on the number of concluded contracts.

Based on the presented results, hypothesis **H3** (*personality traits affect risk management*) can be **confirmed** for the dimensions of **extraversion**, **agreeableness**, and **conscientiousness**. For the dimensions of **neuroticism**, **openness to experience**, and **tolerance of ambiguity**, no influence on the conclusion of insurance contracts was established, and thus, the hypothesis for these variables must be **rejected**. Hypothesis **H4** (*risk identification affects risk management*) can be **confirmed** for the influence of **risk awareness** on the conclusion of **disability** and **accident insurance** contracts. This hypothesis must be **rejected** for its influence on the conclusion of **legal** and **private pension insurance** contracts. For hypothesis **H5** (*risk assessment affects risk management*), the influence of **risk probability awareness** can be **confirmed** for the conclusion of **disability** and **private pension insurance** policies, as well as for the **total number of insurance contracts concluded**. **Damage magnitude awareness** and **risk attitude** showed **no effect** on the conclusion of insurance contracts, and therefore, this hypothesis must be **rejected** for these two variables.

Subsequently, results of **multiple regression analysis** were tested and presented for **risk attitude**, **average risk probability awareness**, and **average damage awareness** as dependent variables, in order to test hypotheses **H1** and **H2**.

For **risk awareness** as the dependent variable, it was not possible to model a regression function due to insufficient significant values. Therefore, the **influence of personality traits on risk awareness** cannot be confirmed, and **H1** (*personality traits influence risk identification*) must be **rejected**.

Using multiple regression analysis with **risk attitude** as the dependent variable, **no connection** was found between **age**, **net income**, **agreeableness**, **ambiguity tolerance**, and **risk attitude** (see Table 3).

Table 3. Multiple Regression Analysis of Risk Attitude

Variable	Coefficient	p-value
ßo	5,432	<0,0001
ß1 (age)	-0,072	0,0017
ß2 (net income)	0,462	0,003
ß3 (tolerability)	-0,173	<0,0001
ß4 (tolerance for ambiquity)	0,088	<0,0001

Table 4. Multiple Regression Analysis of Acceptance of Event Probability

Variable	Coefficient	p-value
ßo	4,222	<0,0001
ß1 (extroversion)	-0,05	0,0147

Age and agreeableness show a **negative influence** on risk attitude. More agreeable and older respondents demonstrate **lower risk readiness**, in contrast to younger participants and those with a lower level of agreeableness. **Net income** as well as **tolerance of ambiguity** are positively correlated with risk attitude. A higher tolerance for ambiguous situations may lead to greater risk willingness, which implies a **positive influence** between risk attitude (a higher item value in the risk attitude scale indicates greater risk readiness) and tolerance of ambiguity. Higher net income, based on greater risk tolerance, may also lead to increased risk willingness.

The **coefficient of determination** for assessing the global value of this regression is **r = 0.3087**, which means that **30.87% of the variance** in the dependent variable, **risk attitude**, can be explained by the four independent variables (age, net income, agreeableness, and tolerance of ambiguity).

Based on the results of the regression analysis for the dependent variable **"average acceptance of probability"**, a **positive correlation** can be confirmed between **extraversion** and **acceptance of probability** (*see Table 4*).

There is a **negative correlation** between the **dimension of extraversion** and the **average acceptance of the probability** of the investigated risks. This connection can be explained by the **optimism** and **positive emotions** of individuals with a high degree of extraversion (ibid, p. 11). Due to their emotional positivity and a stronger focus on gains in contrast to losses, negative events may be **less readily accepted**, and consequently, their probability is **underestimated**.

The **coefficient of determination** for evaluating the value of this regression is **r = 0.0486**, which means that **4.86% of the variance** in the dependent variable, **average acceptance of probability**, can be explained by the independent variable **extraversion**.

Table 5. Multiple Regression Analysis of Acceptance of Damage Severity

Variable	Coefficient	p-value
ßo	3,735	<0,0001
ß1 (net income)	-0,3	0,0011
ß2 (conscientiousness)	0,076	0,0145

For the regression analysis with the average accepted magnitude of damage, the results indicate a correlation between net income, the expression of conscientiousness, and the average accepted damage amount (see Table 5).

The trait of conscientiousness shows a **positive correlation** with the average accepted amount of damage. This can be explained by an increased loss aversion and a heightened sensitivity to losses among conscientious individuals, whose level of conscientiousness is high. Losses are more intensely perceived

and evaluated by individuals with pronounced conscientiousness than by those with lower levels of this trait.

The **negative correlation** between net income and the average accepted magnitude of damage can be explained by the **reflection effect**. Individuals always evaluate outcomes in relation to their personal reference points. Higher net income may, depending on differing reference points, lead to a **lower assessment of financial losses** in the event of risk. The coefficient of determination for the explanatory power of this regression is **r = 0.1009**, i.e. **10.09%** of the variance of the dependent variable — the average accepted amount of damage — can be explained by the two independent variables: net income and conscientiousness.

The presented results show that **personal characteristics influence risk assessment**. Risk attitude, the average accepted probability, as well as the average accepted magnitude of damage are all **correlated with at least one of the examined personality traits**. Risk attitude is influenced by the traits of **agreeableness** and **tolerance of ambiguity**. The average accepted probability has a **negative correlation** with the trait of **extraversion**, and the average accepted damage amount is **influenced by conscientiousness**.

Based on these results, **hypothesis H2** (*personality traits influence risk assessment*) is **confirmed**. However, for the personality traits **neuroticism** and **openness to experience**, the hypothesis must be **rejected** due to insufficient correlation with risk assessment.

6. Limitations of the Study and Practical Implications

This study aims to improve the understanding of individual behavior when making decisions about purchasing insurance and to expand knowledge about the impact of fundamental personality traits, as well as other factors in individual risk assessment. The objectives of this study were to analyze the relationship between personality traits, individual risk assessment, and the conclusion of insurance contracts.

The presented results reinforce the assumption that personality traits, as well as risk awareness, significantly influence the decision to purchase insurance. For this purpose, various insurance products were tested individually in relation to the aforementioned influencing factors. The conclusion is that each type of insurance has its own **specific influencing factors**, which lead to the decision to purchase that particular type of insurance. Therefore, it is **not possible to generalize** the influencing factors for insurance as a broad category.

A surprising finding in the analysis of the collected data is that **no correlation could be established between the personality trait neuroticism and the act of concluding an insurance contract**. Neuroticism is often associated with heightened loss aversion and emotional negativity, which are typically linked to strong perceptions of negative events and should, therefore, theoretically support the decision to purchase insurance.

The research results presented here are of **special interest to insurance companies**, as they help to better understand the key factors influencing the purchase of different types of insurance. These insights should be used to offer more suitable insurance products to the population, thereby increasing the number of concluded contracts. **Marketing departments** in insurance companies should leverage this knowledge — the link between personality traits and their influence on purchasing decisions — to educate the public through, for example, social media, about suitable insurance products that would better resonate with them.

As is typical and expected for all research projects, this study is also subject to certain **limitations**. The sample analyzed was of appropriate size (sufficiently large) to conduct quality statistical analysis using the selected techniques and methods. One of the major limitations is related to the **demographic characteristics** of the sample — although respondents were selected randomly, the **average age was about 27 years**, which **does not allow** for generalizing the findings to the **entire population of Bosnia and Herzegovina**, as age group representation was not met.

Additionally, the **number of male respondents** was relatively low (about **34%** of the total sample), which also limits the generalization of findings to the entire population. Therefore, the obtained results **must be critically viewed**, as they are **not representative** of the entire population of Bosnia and Herzegovina.

Due to the random selection of respondents (a prerequisite for regression analysis), generalization of the results is limited. However, the influence of personality traits and individual risk management variables on the conclusion of insurance contracts **should not be dismissed**, as they offer meaningful insights for understanding the studied phenomenon and for drawing conclusions based on the results.

This research applied **logistic regression** and **multiple regression analysis** to examine the **direct relationship** between the observed variables.

Furthermore, this type of study is **not capable** of explaining the relationship between **economic-monetary** factors and **psychological** factors in the decision-making process regarding insurance purchase. **Available net income** was considered in the research and showed varying influence on the conclusion of insurance, such as **private pension insurance** or **disability insurance**. It remains an open question whether available net income **creates a "cluster"** of factors that together lead to the decision to conclude insurance. This study stands somewhere along the path of proving that hypothesis with its final results.

Net income in itself is more specific in its association with overall household income and its influence on financial care responsibilities. In this regard, a more detailed analysis of **individual risk assessment processes** would be beneficial. Risk analysis and its assessment are gaining significance in the framework of **risk management according to ISO standards**, where it holds **a central role** (ISO 31000:2018, see Figure 1).

In conclusion, for the research conducted and the results obtained, it can be stated that, thanks to the conceptual foundation of analyzing **individual risk management** and the **factors influencing insurance decisions**, an important contribution has been made to the study of behavior in the decision-making process regarding insurance.

There is a **strong need for such research in our region**, as this topic is **neglected in local literature and practice**. Further in-depth research into **affective and individual influencing factors** on insurance decisions is certainly necessary in order to provide a more detailed **description of individual behavior** when deciding whether to conclude an insurance contract.

7. Recommendations for Further Research

This paper is intended to serve merely as a modest example and guideline for a much more comprehensive study and research on the topic of analyzing factors relevant to the conclusion of different types of insurance contracts. It should focus on the correlation between personal characteristics of potential insurance policyholders and their individual tendencies related to risk tolerance or risk-bearing capacity.

At the end of this paper, all the limitations and shortcomings that accompanied the research process and the obtained results are listed. These should be carefully considered in any future work on this or a similar topic in order to avoid them.

A comprehensive study should be conducted on a sufficiently large sample, which would provide the research and its findings with the necessary scientific credibility. Research of this scope could, for example, be the subject of a doctoral dissertation or, even better, a joint project by students from a university under the appropriate mentorship of their professors.

References

1. Brachinger, Wolfgang, H., Weber, M.: Risk as a primitive: a survey of measures of perceived risk. Or Spektrum 19, 235–250 (1997)
2. Benischke, M.H., Martin, G.P., Glaser, L.: CEO equity risk bearing and strategic risk taking: The moderating effect of CEO personality. Strat Mgmt J 40, 153–177 (2019)
3. Durkin, T.A., Elliehausen, G.: New evidence on an old unanswered question: the decision to purchase credit insurance and other debt protection products. J. Insur. Regul. 37(9), 1–22 (2018)
4. Ernst, Rogler, : Berufsunfähigkeitsversicherung, Nomos, (2018)
5. Finke, M.S., Belasco, E., Huston, S.J.: Individual property risk management. J. Probab. Stat. 2010, 1–11 (2010)
6. Foitzik, Grünerweald: Lebensversicherung und betriebliche Altersverorgung, Bwv, (2023)
7. Grill, Lindner, Lüpertz: Versicherungen und Finanzanlagen kompetent beraten, Europa Lehrmittel, (2023)
8. Härle, Saidole, Ter Schmitten: Kranken- und Unfallversicherung, Bwv, (2023)
9. Häusler, A.N., et al.: Why would you buy insurance? The association between Insurances and personality traits. Rheinische Friedrich-Wilhelms-Universität, Bonn (2019)
10. Kunkel, B.: Total ver(un)sichert, FBV, (2022)

11. Lauriola, M., Weller, J.: Personality and risk: daredevils—risk taking from a temperament perspective. U: Raue, M., Lermer, E., Streicher, B. (Hrsg.) Psychological perspective on risk and risk analysis—theory, models, and applications. Springer, Cham (2018)
12. Liebwein, P.,: Klassische und moderne Formen der Rückversicherung, VVW, (2018)
13. Norton, R.W.: Measurement of Ambiguity Tolerance. Journal of Personality Assessment 39(6), 607–619 (1975)
14. Robold, Berthold, Schmitz: Sachversicherungen für Private und Gewerbliche Kunden, Bwv, (2023)
15. Romeike, F.: Risikomanagement. Springer, Wiesbaden (2018)
16. Slovic, P.: Perception of risk. Science 236, 280–285 (2000)
17. Slovic, P., et al.: Risk as analysis and risk as feelings: some thoughts about affect, reason, risk and rationality. Risk Analysis 24, 311–322 (2004)
18. Theil, M.: Versicherungsentscheidungen und Prospect Theory: Die Risikoeinschätzung der Versicherungsnehmer als Entscheidungsgrundlage. Springer, Wien (2002)
19. Thürmann, Kettler: Produkthapftlichtversicherung, VVW, (2019)
20. Tversky, A., Kahneman, D.: Availability: a heuristic for judging frequency and probability. Cogn Psychol 5, 207–232 (1973)
21. Wang, H.-F., Hsu, F.-C.: An integrated operation module for individual risk management. Eur J Oper Res 198, 610–617 (2009)
22. Zech, J.: Integriertes Risikomanagement—Status quo und Entwicklungstendenzen aud der Perspektive eines Versicherungskonzerns. U: Hölscher, R., Elfgen, R. (Hrsg.) Herausforderung Risikomanagement: Identifikation, Bewertung und Steuerung industrieller Risiken, str. 33–49. Gabler, Wiesbaden (2002)

Mr. sci. Edin Skokić[1] *Preliminary communication*

VIRTUAL FAITH: RELIGION IN BOSNIA AND HERZEGOVINA IN THE DIGITAL AGE

Abstract

This paper analyzes the transformative effects of the internet and digital technologies on religious practices and expressions of religiosity in contemporary Bosnian-Herzegovinian society. Starting from the premise that the digital environment does not merely serve as a neutral channel for disseminating religious content but actively participates in shaping and redefining religious discourse, identity, and community, the study focuses on how traditional religious institutions and individual believers engage with online spaces for religious purposes. Special attention is given to the specific context of Bosnia and Herzegovina, whose characteristics—multi-religious composition, complex historical experiences, and post-conflict social dynamics—significantly influence digital religious practices. The methodological framework combines qualitative and quantitative approaches, including content analysis of religious websites, social media profiles, and online forums, as well as data collected through surveys and semi-structured interviews with believers and religious leaders. The aim of the study is to identify dominant patterns of digital religiosity, such as the popularization of religious education, the formation of virtual communities, transformations in the religious identity of youth, and the challenges and opportunities related to the promotion of interfaith dialogue in contrast to the spread of disinformation and radical narratives. Findings indicate profound changes in the religious landscape of Bosnia and Herzegovina, with digital media emerging as a crucial space for the reinterpretation of faith. In this context, understanding the phenomenon of "virtual faith" becomes essential for a comprehensive examination of contemporary forms of religious expression and belonging.

Key words: *Digital Religiosity, Religion And The Internet, Virtual Faith, Social Media, Religious Communities, Online Religion, Interfaith Dialogue.*

1 International Business Information Academy Tuzla, skokic.e@gmail.com

1. Introduction

Digital technology has transformed nearly every aspect of contemporary society, including religious experience. Faith, traditionally associated with physical places of worship and direct community interaction, is increasingly shifting into virtual environments. The internet and digital media have become not only channels for distributing religious content, but also spaces where religious identity, community, and discourse are constituted (Cheong et al., 2012). This transformation is not merely a technological shift, but a complex process that affects the ways in which people believe, communicate, and practice their faith.

Within these changes, research suggests that the digital sphere facilitates broader access to religious messages while simultaneously creating space for the reinterpretation of traditional norms (Campbell, 2012). In such a context, believers increasingly assume active roles—not only as recipients of religious content, but also as its producers, curators, and disseminators. At the same time, online religious practice often reflects dominant patterns of cultural, political, and economic relations within specific social contexts (Helland, 2000).

Bosnia and Herzegovina, as a multi-religious and post-conflict society, represents a particularly interesting setting for the study of digital religiosity. Its complex religious landscape and dynamic media environment allow for the exploration of how various religious communities, as well as individuals, use digital technologies to spread religious teachings, build communities, and reaffirm identity (Krčalo & Džafić, 2024). Special attention is paid to youth, who are simultaneously the most exposed to digital influences and the key agents of religious change.

In modern society, digital technologies are increasingly penetrating various aspects of human life, including religion. The digital era is shaping new forms of religiosity, enabling believers to experience faith through online spaces, applications, social media, and virtual communities. In this context, the goal of this paper is to analyze how the internet and digital platforms are transforming religious practice, expressions of faith, and collective religious identity in Bosnia and Herzegovina.

Bosnia and Herzegovina, as a multi-religious and post-conflict society, offers a particularly compelling field for examining digital religion. Traditional religious communities are increasingly using digital channels to communicate with their members and engage with the broader society. On the other hand, believers—especially young people—are increasingly shaping their own religious experiences in digital environments, often independently of institutional structures.

The aim of this paper is to explore the forms and meanings of digital religiosity in the context of contemporary Bosnia and Herzegovina, through the analysis of the online presence of religious communities, believers' behaviors, and the phenomenon of Virtual Faith. This introductory chapter outlines the theoretical and socio-political framework that enables a deeper understanding of the relationship between religion and digital culture.

This study starts from the thesis that the digital environment is not a neutral channel for the dissemination of religious content but actively shapes religious discourse, identity, and community. The research is based on a combination of qualitative and quantitative methods, including the analysis of religious websites, social media platforms, and forums, as well as a survey of citizens.

2. Theoretical Framework

In examining the relationship between religion and digital technologies, it is important to introduce three key concepts: "religion online," "online religion," and "digital religion." The first term, religion online, refers to situations where religious communities use the internet as a tool for disseminating pre-existing messages and information—such as announcements of religious events, livestreams of liturgies, or distribution of religious materials (Helland, 2000). In contrast, online religion implies active user participation in religious practices within the digital space—including communal prayer, discussions, virtual rituals, and the formation of digital faith communities (Helland, 2000).

The concept of *digital religion* further expands upon the previous notions. This term, introduced into academic discourse by Heidi Campbell, refers to the broader processes through which digital technologies not only mediate religion but also contribute to the transformation of its very essence—through new forms of expression, identification, and community (Campbell, 2012).

According to Cowan and Dawson (2004), the internet represents an "expanded space" in which religious practice is no longer tied to physical presence but can be realized within digital communities that produce a new form of "virtual belonging." These communities may or may not be connected to official religious institutions, thereby challenging the hierarchical structure of authority in traditional religion.

Krčalo and Džafić (2024) emphasize that digital religion does not merely mediate communication but redefines the symbolic language of religion—transforming faith into an experience that is simultaneously public and private, ritualistic and individualized. In this sense, digital religion shapes new patterns of belonging and interpretation of religious meanings.

Within this theoretical framework, the study is based on the idea that digital media are not merely tools, but active agents in the construction of contemporary forms of religiosity.

3. Religion and Digital Media in Bosnia and Herzegovina

Bosnia and Herzegovina represents a unique case in terms of religious pluralism and historical heritage, which is directly reflected in the digital media practices of religious communities. The Islamic Community in BiH, the Catholic Church, and the Serbian Orthodox Church maintain a presence on the internet through official websites, social media platforms, and multimedia content aimed at believers of various generations.

Particular attention should be paid to young people, who are the most active users of digital technologies. Previous research (Krčalo & Džafić, 2024; Cheong et al., 2012) indicates that significant shifts in the experience and practice of faith are most visible among youth. Instead of relying solely on institutional frameworks, religious knowledge is increasingly acquired through personalized sources: YouTube preachers, TikTok videos, and Instagram posts. Young believers frequently follow religious influencers, among whom Elvedin Pezić stands out as one of the most prominent.

The case of Elvedin Pezić, a well-known Islamic preacher and khatib, illustrates the complexity of the digital religious landscape. His content on YouTube and Facebook garners hundreds of thousands of views, and comments under his posts reveal strong interaction between the audience and the preacher. Pezić uses a language that resonates with young people, while remaining grounded in traditional Islamic interpretation. This contributes to his popularity, but also generates controversy. His example demonstrates how digital media enable a reinterpretation of religious authority.

Alongside positive aspects, challenges are also present in the digital religious space of BiH. The emergence of disinformation, radical interpretations, and polarizing narratives—often amplified by social media algorithms—can foster intolerance among religious communities. Nonetheless, there are also encouraging examples: online prayer communities, interfaith forums, and joint campaigns promoting dialogue and mutual understanding (Cowan & Dawson, 2004). In conclusion, digital media in Bosnia and Herzegovina do not merely mirror existing religious practices, but serve as laboratories for their transformation. Their influence is most pronounced among young people, yet they are gradually reshaping broader patterns of religious communication, presence, and belonging.

Bosnia and Herzegovina is a country of marked religious diversity, where Islam, Orthodoxy, Catholicism, and Judaism are historically rooted and institutionally present. This multiconfessional structure—shaped by complex historical, political, and social processes—is reflected in how religion is perceived and practiced in contemporary society. The role of religion in BiH is not only spiritual, but also cultural, political, and identity-based. In recent decades, religious communities in BiH have increasingly utilized digital platforms. The Islamic Community in BiH, the Catholic Church, the Serbian Orthodox Church, the Jewish Community, as well as smaller Protestant and other religious groups, have developed their own websites, YouTube channels, and social media profiles (Facebook, Instagram), using digital tools to disseminate religious content, inform the public, and engage with believers. This practice can be classified as "religion online" (Helland, 2000), as it primarily involves one-way communication and the transmission of pre-established religious knowledge. However, forms of "online religion" are also evident, particularly among younger generations. Young people in BiH, who are digitally literate and active social media users, often shape their own religious experiences through online prayer groups, forums, TikTok and YouTube content. This enables a personalized religious practice that operates outside institutional frameworks and is open to a variety of interpretations and influences (Campbell, 2012).

The formation of virtual religious communities is becoming more pronounced, especially in the context of increasing geographic mobility, social fragmentation, and declining trust in traditional institutions. These communities often represent safe spaces for sharing spiritual experiences, exchanging opinions, and fostering a sense of belonging. On the other hand, digital media also bring challenges such as the spread of religious disinformation, radical interpretations, and the erosion of authority in religious discourse. Through digital media, religion in Bosnia and Herzegovina acquires a new dimension—it becomes more accessible, flexible, and interactive, yet simultaneously more vulnerable to the risks of the modern information society.

4. Research Methodology

This study employed a mixed-methods approach, integrating both qualitative and quantitative methods in order to provide a comprehensive understanding of the phenomenon of digital religiosity in Bosnia and Herzegovina. The research encompassed three complementary methods: content analysis, a survey, and a case study.

The official websites and social media accounts of the most prominent religious communities in Bosnia and Herzegovina (the Islamic Community, the Catholic Church, and the Serbian Orthodox Church) were analyzed during the period from January to July 2025. The focus was placed on the topics, language, form, and frequency of posts, as well as on user interaction. A descriptive content analysis was conducted to identify dominant patterns of digital communication.

To collect data on users' attitudes and behaviors, an online survey was conducted using the Google Forms platform. A total of 108 respondents from various regions of Bosnia and Herzegovina participated in the survey. The questionnaire consisted of 12 questions, including demographic information, use of digital media for religious purposes, perception of religious authorities online, and frequency of participation in digital religious practices.

The case study focused on the work of Mr. Elvedin Pezić, one of the most prominent Islamic preachers in the Bosnian digital space. The analysis covered his video content (YouTube, Facebook), discourse, communication style, and interaction with the audience, drawing on previous research and publicly available sources (e.g., BIRN reports, media analyses, viewership statistics).

The study adhered to ethical principles of anonymity and voluntary participation in the survey. Research limitations include a relatively small sample size, a limited time frame, and the inability to fully verify content on informal digital channels.

5. Case Study – Mr. Elvedin Pezić

Mr. Elvedin Pezić represents one of the most prominent examples of a digitally active religious authority in Bosnia and Herzegovina. His presence on YouTube, Facebook, and other platforms such as TikTok and Instagram reflects inten-

sive use of digital media for religious education and communication with the public. According to available data, his video content reaches several hundred thousand views, placing him among the most influential Islamic speakers in the region.

Pezić employs a direct communication style, adapted to everyday language and closely aligned with a younger audience. Through formats such as video lectures, Friday sermons (khutbah), and Q&A sessions, he addresses topics relevant to youth—marriage, parenting, social media, morality, identity—interpreting them from a conservative Islamic perspective. His popularity stems from a combination of traditional religious knowledge and modern media expression, making him an accessible and influential voice among young Muslims.

A key aspect of Pezić's work is his positioning as a religious educator and moral authority. He does not act as an official representative of the Islamic Community, but rather operates independently from institutional frameworks, which allows for greater flexibility and direct engagement with his audience. His role can be understood through the concept of the "individualized religious authority" in the digital age, as defined by Helland (2005) and Campbell (2012).

While many see his work as an affirmation of Islamic values and a counterbalance to secularism, Pezić's content also generates controversy, particularly regarding his interpretations of women's rights, gender roles, and attitudes toward "the other." Critics associate him with a Salafi interpretation of Islam which, although not inherently violent, promotes social conservatism. A 2019 BIRN investigation noted his substantial online following and suggested that such influence, while legal and non-violent, can shape social norms toward exclusivity and intolerance.

Pezić's digital identity is built on a blend of religious scholarship, personal mission, and communication strategies typical of digital influencers. He posts content regularly, engages with comments, and leverages platform algorithms to expand the reach of his messages. This approach aligns with the concept of "religious digital entrepreneurship," where religion is interpreted and distributed through mechanisms of popular culture and the attention economy.

This research has shown that digital religiosity in Bosnia and Herzegovina increasingly manifests through a combination of 'religion online' and 'online religion' models. Content analysis of the official online profiles of religious communities revealed diverse approaches to digital communication—from institutional and informational forms to interactive and multimedia practices. The Islamic Community stands out in terms of frequency of posts and presence of educational content. The survey revealed that young users of digital media perceive social networks as important sources of religious knowledge, as well as spaces for interreligious dialogue—though concerns remain regarding the spread of misinformation. The case study of Elvedin Pezić further highlighted the influence of individual religious authorities on the internet. Digital religiosity is emerging as a key phenomenon for understanding contemporary expressions of faith, calling for broader and deeper interdisciplinary research in the future.

6. Descriptive Content Analysis: The Digital Presence of Religious Communities in Bosnia and Herzegovina

As part of the research on digital religiosity, a descriptive content analysis was conducted of the official websites and social media profiles (Facebook, Instagram, YouTube) of the four main religious communities in Bosnia and Herzegovina: the Islamic Community, the Catholic Church, the Serbian Orthodox Church, and the Jewish Community. The analysis covered a 30-day period (June 2025) and focused on the following aspects: frequency of posts, thematic focus, multimedia formats, user interaction, and the presence of the "religion online" and "online religion" models (Helland, 2000; Campbell, 2012).

Islamic Community in Bosnia and Herzegovina

A high frequency of posts was recorded, with dominant themes including Ramadan activities, Friday sermons (khutbahs), and messages from the Grand Mufti. Multimedia formats (videos and infographics) are well represented, with Facebook being the most active platform. A balance is observed between the "religion online" model (content distribution) and "online religion" (interactive sections, live streaming of prayers and public forums). The Islamic Community operates BIR TV and BIR Radio, and commercial religious TV channels such as MTV Igman and Kanal 5 also exist in Bosnia and Herzegovina.

Catholic Church in Bosnia and Herzegovina

Posts are regular, with a focus on mass schedules, bishop messages, and religious holidays. Video content (masses, priest messages) is most commonly found on YouTube channels. Interaction with users is limited, indicating a predominant use of the "religion online" model.

Serbian Orthodox Church (SOC) in Bosnia and Herzegovina

The digital presence is institutionally structured but less frequent compared to other communities. The focus is on liturgical content (services, holidays, festive messages). Text-based formats dominate, with low levels of user interaction.

Jewish Community in Bosnia and Herzegovina

Digital presence is more modest, but the content is educational and cultural in nature. Cultural events, historical memory, and interfaith dialogue are promoted. Multimedia use is limited, and activities are more frequently visible on Facebook and in the form of news items on websites.

The analysis shows that all four communities rely on digital media to communicate with their members, but to varying degrees and with different strategies. The Islamic Community demonstrates the highest level of digital activity and diversity of formats. The Catholic and Orthodox Churches maintain an institutional tone with limited two-way communication. The Jewish Community uses digital platforms for education and intercultural promotion. Through the lens of theoretical models (Helland, 2000; Campbell, 2012), the dominance of the "religion online" model is evident, while examples of "online religion" are present but limited to specific initiatives and individuals.

7. Results of the Empirical Research

In the empirical part of the research, a questionnaire specially designed for this study was used. A total of 108 respondents participated. The structure of the respondents by gender, age, and religious affiliation is shown in Figure 1, Figure 2, and Table 1. Respondents come from various parts of Bosnia and Herzegovina, with an emphasis on urban areas such as Sarajevo, Tuzla, and Banja Luka.

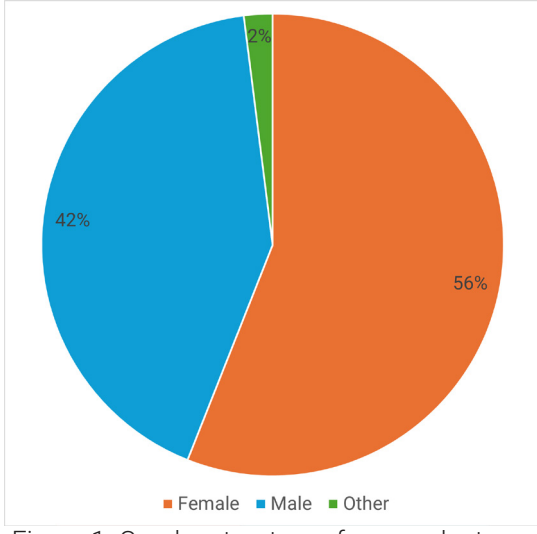


Figure 1. Gender structure of respondents

Source: Author

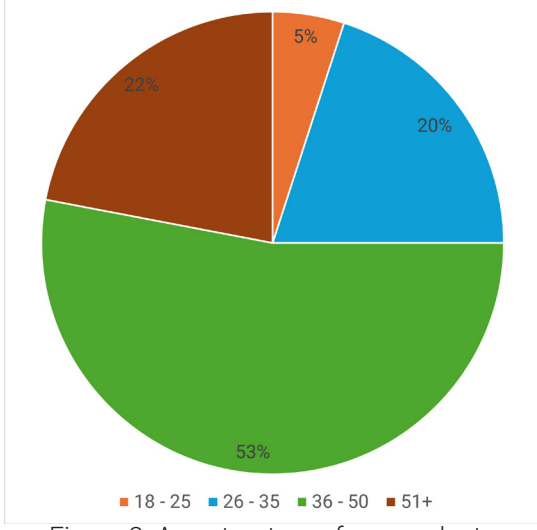


Figure 2. Age structure of respondents

Source: Author

Table 1. Religion structure of respondents

Religion	Percentage
Islamic Community	74.1%
Catholic Church	13%
Serbian Orthodox Church	2.8 %
Other	11. 1%

Source: Author

Table 2 shows how often respondents consume religious content via the Internet. The largest number of respondents (38%) consume religious content on the Internet once or twice a week, while 28.7% never consume such content online.

Table 2. Consumption of religious content through the Internet

	Percentage
Never	28.7 %
Once or twice a week	38%
Three to five times a week	15.7 %
Once a month	0.9 %
Every now and then	0.9 %
Very rarely	0,90%
On weekends	0.9 %
More than five times	11.1 %
Other	3.8 %

Source: Author

The results presented in Table 3 show that the largest number of respondents (39.8%) use Facebook as a platform for following religious content, while the smallest number (4.6%) use Instagram and TikTok for this purpose.

Table 3. Digital platforms for consuming religious content

Digital Platform	Percentage
Facebook	39.8 %
YouTube	15.7 %
Instagram	4.6 %
TikTok	4.6 %
WEB	16.7 %
Other	18.5 %

Source: Author

Table 4 shows the forms of religious content consumed by respondents. Text-based content is consumed by 49.1% of respondents, video content by 38%, and audio content by only 0.9%.

Table 4. Form of religious content

Form of religious content	Percentage
Video	38%
Text	49.1%
Audio	0.9%
Interactive	12%

Source; Author

This study´s results indicate that only 7.4% of respondents actively participate in an online religious prayer group, while for 51% of them, the Internet has little or very little significance for religious education. At the same time, only 16.7% of respondents consider the Internet to have great or very great significance for religious education. Only 18.5% stated that they had changed their opinion on a religious topic based on online content.

As many as 87.1% of respondents reported encountering misinformation and radical religious views on the Internet. However, it is encouraging that more than half (51%) believe the Internet is an important channel for interreligious dialogue in Bosnia and Herzegovina.

8. Conclusion

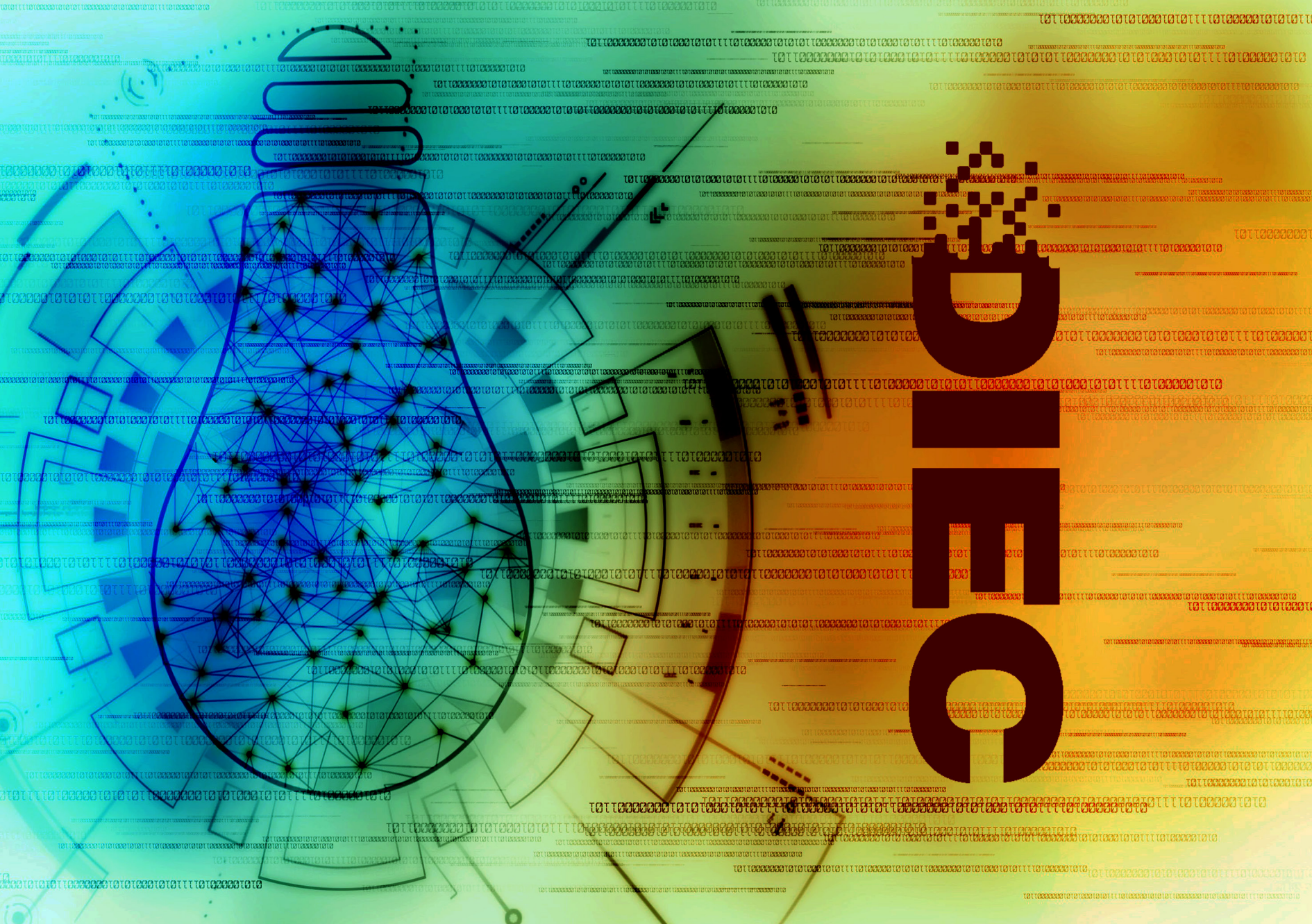
Religion in the digital age of Bosnia and Herzegovina stands at the crossroads of tradition and innovation. On the basis of the results of the survey, it can be concluded that the consumption of religious content on the Internet is relatively low and does not significantly affect religious education or attitudes.The case of Mr. Elvedin Pezić illustrates the ambiguity of digital religion: on the one hand, it offers access to contemporary interpretations of faith; on the other, it can reinforce conservative patterns of thought. These phenomena require a critical approach and a clearer normative framework where religious freedom meets social responsibility. It is important to highlight the ambivalent role of the digital space: on one hand, it facilitates education and interreligious dialogue, while on the other, it allows the spread of radical, oversimplified, and often incorrect interpretations of religion. The future role of religious communities and leaders in Bosnia and Herzegovina's digital space will depend on their ability to balance the authenticity of religious teachings with the dynamic communication needs of modern society. Digital religion presents both a challenge and an opportunity—and understanding it is essential for comprehending the identity, cultural, and political processes in Bosnia and Herzegovina.

One of the limitations of this study is the structure of respondents by religious affiliation, as it does not reflect the actual religious composition of Bosnia and Herzegovina. The relevance of this topic leaves much room for future research, especially regarding the role of the Internet in developing interreligious dialogue in Bosnia and Herzegovina.

References

1. ASTRA. (2025). Report on the State of Human Rights of Women in Bosnia and Herzegovina (2022–2024). ASTRA Network.
2. Boca, I. (2019). Communication of Religious Communities through Social Media (Master's thesis). Faculty of Political Science, University of Zagreb.
3. Campbell, H. (Ed.). (2005). Religion on the Internet: Community and Virtual Existence. Routledge.
4. Campbell, H. A. (2012). Digital Religion: Understanding Religious Practice in New Media Worlds. Routledge.
5. Campbell, H. A., & Bellar, W. (2021). Digital Religion: The Basics. Routledge.
6. Cheong, M. B. (2013). What It Takes to Be an Online Religious Authority. Journal of Contemporary Religion, 28(1), 79–94.
7. Cowan, D. E., & Dawson, L. L. (Eds.). (2004). Religion Online: Finding Faith on the Internet. Routledge.
8. Hasanović, M., & Đozić, M. (Eds.). (2022). The Position of Religion in the Digital Age. Faculty of Islamic Studies, University of Sarajevo.
9. Helland, C. (2000). Online-Religion/Religion-Online and Virtual Communitas. In J. K. Hadden & D. E. Cowan (Eds.), Religion on the Internet: Research Prospects and Promises (pp. 205–224). JAI Press.
10. Helland, C. (2004). Virtual Pilgrimage: Exploring Catholic Communities on the Internet. In L. Dawson & D. Cowan (Eds.), Religion on the Internet: Research Prospects and Promises (pp. 205–232). Routledge.
11. Helland, C. (2005). Online Religion as Lived Religion: Methodological Issues in the Study of Religious Participation on the Internet. Online – Heidelberg Journal of Religions on the Internet, 1(1), 1–16.

12. Krčalo, S., & Džafić, A. (2024). The Position of Religion in the Digital Age. Faculty of Philosophy, University of Sarajevo.
13. Lovrić, A. (2017). Religion as a Worldview (Master's thesis). University of Zadar.
14. Marčetić, H. (2015). The Impact of the Internet on the Formation of Young People's Religious Identity (Master's thesis). Faculty of Humanities and Social Sciences, Josip Juraj Strossmayer University of Osijek.
15. Novak, K., & Valković, J. (2009). Religion and the Internet — New Challenges of Living Faith. Nova Prisutnost, VII(1), 59–67.
16. Radde-Antweiler, K. (2011). Virtual Religion: An Approach to a Religious and Ritual Topography of Second Life. Online – Heidelberg Journal of Religions on the Internet, 4(1), 174–190.
17. Yin, R. K. (2014). Case Study Research: Design and Methods (5th ed.). SAGE Publications.


DEMO